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CONTENTS

No. 1 MAY, 1944

PETER GRUENWALD AND WILLIAM M. KONIKOV. Cell replacement and its relation to the zona glomerulosa in the adrenal cortex of mammals. Three text figures and three plates (twenty-one figures) 1

CARL J. SANDSTROM AND ABRAHAM SALTZMAN. A comparative study of the clavicular ligaments of the rat, rabbit, cat, and dog. Six figures 23

RICHARD A. GROAT. Formation and growth of adrenocortical-like tissue in the ovaries of the adrenalectomized ground squirrel. Two plates (ten figures) 33

P. P. H. DE BRUYN. Locomotion of blood cells in tissue cultures. Six plates (thirty-eight figures) 43

JOSEPH EPSTEIN. A method for visualizing the blood vessels of nerves and other tissues. Two figures 65

GERHARDT VON BONIN. Partial inversion of the duodenum. One figure 71

ROBERT BRIGGS AND LOIS JUND. Successful grafting of frozen and thawed mouse skin. One plate (four figures) 75

W. MONTAGUE COBB. Apical pericardial adhesion resembling the reptilian gubernaculum cordis. One plate (three figures) 87

No. 2 JUNE, 1944

STANLEY P. DRUMMOND. A comparison of the injection and red-cell staining methods used in quantitative studies of the capillaries of the central nervous system. Two figures 93

W. C. GEORGE. A pig embryo with bifid notochord, biaxiate brain with paired hypophyses. One text figure and one plate (eight figures) 107

JOHN O. ALMQUIST AND FREDERICK N. ANDREWS. Effect of testosterone propionate on thermo-regulatory function of rat scrotum 125

KENNETH L. DUKE. Activity of the germinal epithelium in the ovary of a pregnant harvest mouse. One plate (six figures) 135

EBEN J. CAREY. Early effects of inanition on the structure of motor end plates. Three plates (seven figures) 139

JAMES H. LEATHEM. Influence of testosterone propionate on the adrenals and testes of hypophysectomized rats 155

ALEXEI A. KONEFF. Effect of adrenocorticotropic hormore (ACTH) on the anterior pituitary of the adrenalectomized young male rat. One plate (eleven figures) 163

C. M. KIRKPATRICK. Body weights and organ measurements in relation to age and season in ring-necked pheasants. Sixteen figures 175

AMERICAN SOCIETY OF ZOOLOGISTS. 1944. No meeting held. Officers, constitution and by-laws, proceedings and list of members 195

No. 3 JULY, 1944

Herbert S. Kupperman, Roland K. Meyer and John C. Finerty. Ovarian hypertrophy in rats united in parabiosis with littermates previously treated with antigonadotropic sera ... 277

Alden B. Dawson. A note on the argentaffin cells of the gastric mucosa of the rat. One plate (three figures) ... 287

Charles E. Tobin. The renal fascia and its relation to the transversalis fascia. Twelve figures ... 295

Alexis L. Romanoff. The heart beat of avian embryos. Four figures ... 313

C. M. Kirkpatrick and F. N. Andrews. Development of the testis in the ring-necked pheasant. One text figure and one plate (four figures) ... 317

Edmond J. Farris and Eleanor H. Yeakel. Breeding and rearing of young by albino rats subjected to auditory stimulation ... 325

Grant Litster Rasmussen. A cellophane strip method especially adapted for the preparation and study of Marchi-treated serial sections. Three figures ... 331

Simon B. Chandler and Melvin Schadewald. Studies on the inguinal region. I. The conjoined aponeurosis versus the conjoined tendon. Three figures ... 339

W. Gardner Lynn. Duplicitas anterior in the toad, Eleutherodactylus alticola. Two text figures and two plates (fourteen figures) ... 345

W. Robert Eadie. Tooth replacemeent in Brewer's mole. One plate (four figures) ... 357

American Association of Anatomists. Proceedings, officers and list of members ... 361

No. 4 AUGUST, 1944

Theodore Snook. The guinea-pig spleen. Studies on the structure and connections of the venous sinuses. Three plates (twenty-nine figures) ... 413

H. S. Fish, P. D. Malone and C. P. Richter. The anatomy of the tongue of the domestic Norway rat. I. The skin of the tongue; the various papillae; their number and distribution. Six figures ... 429

Lucie Welles Barber. Correlations between wound healing and regeneration in fore-limbs and tails of lizards. Two plates (fifteen figures) ... 441

Oliver P. Pearson and Charles F. Bassett. Size of the vulva in the fox and its relation to fertility. Four figures ... 455

Owen Lewis Thomas. A cytological study of the secretion antecedents of rat thyroids activated by thiourea. Two plates (six figures) ... 461

William C. Young. Genital cycles following incomplete oophorectomy in the chimpanzee. Ten figures ... 475

Arthur F. Reimann, Edward H. Daseler, Barry J. Anson and Lindsay E. Beaton. The palmaris longus muscle and tendon A study of 1600 extremities. Three figures ... 495

Robert A. Littleford and Helene M. Gysin. Observations on superfetation in mice ... 507

American Society of Zoologists. Program, and abstracts, officers and index of authors ... 515

CELL REPLACEMENT AND ITS RELATION TO THE ZONA GLOMERULOSA IN THE ADRENAL CORTEX OF MAMMALS

PETER GRUENWALD AND WILLLIAM M. KONIKOV
Departments of Histology and Anatomy, Middlesex University School of Medicine, Waltham, Massachusetts

THREE TEXT FIGURES AND THREE PLATES (TWENTY-ONE FIGURES)

It is not incidental that many investigators have directed their attention toward the problem of replacement of cortico-adrenal cells. The adrenal cortex is very sensitive to normal and abnormal stimulation, as well as to damaging agents. Many of its reactions require rapid new formation of cells, either in order to replace damaged and worn parenchyma, or to produce hypertrophy. This can be accomplished by two mechanisms, namely, multiplication of differentiated cortical cells, and differentiation of these cells from other sources. According to reports in the literature, both processes actually occur. Multiplication of cortical cells occurs at the boundary of the zona glomerulosa and fasciculata; details and additional references may be found in reports by Hoerr ('31) and Blumenthal ('40). Differentiation of new cortical tissue from the capsule (or a subcapsular blastema) was described in normal adrenals by Zwemer ('36), Zwemer, Wotton and Norkus ('38), Bachmann ('39), Salmon and Zwemer ('41), Gruenwald ('42), and Wotton and Zwemer ('43), and in regenerating organs by Baker and Baillif ('39). These two regions of cortical cell formation are separated by a layer commonly referred to as zona glomerulosa. This term is most appropriately applied in the case of those species in which the peripheral layer of the adrenal consists of large epithelial arches, or glomeruli. However, the same name has also been used for the corresponding layer in other mammals, including man.

The mechanism of cell replacement by mitoses in the outer part of the zona fasciculata offers no mechanical problems. It is generally assumed that all cells move from that region toward the zona reticularis, and the zona glomerulosa is obviously not concerned with this process. However, cortical cords newly formed in the capsule must pass through the zona glomerulosa in order to reach the zona fasciculata

THE ANATOMICAL RECORD. VOL. 89, NO. 1
MAY, 1944

where, according to all reports, they discharge their specific function. This process of incorporation of newly formed cortical cell groups into the zona glomerulosa is the subject of the present report. At the same time, this study sheds some light on the function of the zona glomerulosa itself which has not received due consideration in the past, perhaps because of the puzzling structural variability of this zone in various mammals.

The only indication of the manner in which cortical cords connect with the cortex after their differentiation in the capsule, was given by Zwemer, Wotton and Norkus. In a diagram which is apparently based on observations in human and monkey adrenals, these authors show how each newly formed cord connects end-to-end with the oblique peripheral portion of a cord of the zona glomerulosa. It was then pointed out by Gruenwald that this mechanism cannot occur in those mammals in which the glomerulosa consists of large arches of cortical cells, with no free ends directed toward the capsule. The present observations show that in addition to the process described by Zwemer and his coworkers, another mechanism exists by which newly differentiated cortical tissue can be incorporated in any type of zona glomerulosa.

MATERIAL AND METHODS

The present study is based predominantly on adrenals of mature mammals, including man. However, organs of embryos and immature animals were also available, and will be referred to in several instances. Part of this material had previously been used by one of us (Gruenwald, '42). Most of the organs were preserved in Bouin's fluid, and serial sections of at least part of the adrenal were made in almost all cases. Azan stain and silver impregnation of the reticulum (method of Gomori) were used throughout, the latter sometimes with a faint counterstain of azocarmine, acid fuchsin or acid alizarin blue. The material includes more than fifty human adrenals, organs of eight young and ten adult cats, seven dogs, twelve rabbits, twenty-eight guinea pigs, and a few specimens of the rhesus monkey, rat, pig and horse. Embryonic adrenals were available of man, cat, dog, guinea pig, cattle, sheep and pig.

Unilateral adrenectomy was performed in a number of guinea pigs and rabbits in an attempt to stimulate hypertrophy in the remaining adrenal, and thus accentuate the changes leading to new formation of cortical tissue. However, no significant results were obtained.

OBSERVATIONS

Our findings in the adrenals of man and the rhesus monkey have fully confirmed the above mentioned concept of Zwemer, Wotton and Norkus concerning the mechanism of incorporation of newly differentiated cortical cords in the zona glomerulosa. However, indications of another mechanism were also seen in human material. This latter process can better be studied in other mammals, and these will be described first.

Guinea pig

In the guinea pig the zona glomerulosa is somewhat more conspicuous than in man. End-to-end junction of newly formed cortical cords with those of the old cortex is not a typical occurrence in this species. The adrenals show considerable variability in the structure of their zona glomerulosa and its relation to what we believe to be newly formed cortical tissue. The various forms can readily be arranged in a series covering the process of differentiation of cortical tissue in the capsule, and the formation of a new zona glomerulosa by that tissue. Various phases may be seen on sections of one adrenal; in other words, different areas of the adrenal surface show, at the same time, different stages of replacement of cortical tissue. The earliest phase of new formation has previously been illustrated by Gruenwald ('42, fig. 13): small groups of cortical cells appear between the fiber bundles of the capsule. The following stages are illustrated by the present figures 4 to 7 which show the outlines of the cortical cords by silver impregnation of the lattice fibers. The first of these figures shows the cortical tissue in the capsule in a form which appears on section as solid cords. Examination of serial sections reveals that the actual form is that of irregular plates parallel to the surface of the organ. Figures 5 and 8 show one of these plates much thicker than in the previous stage. It is not always easy to distinguish sections of these plates from longitudinal sections of contracted small arteries. However, the decision can be made by following the structure in serial sections if, particularly with silver impregnation, single sections should leave any doubt. The large plates of cortical tissue eventually break up into many approximately spherical cell balls (fig. 6). It is obvious at this stage, particularly when the cytoplasm is adequately stained, that the underlying cortex has lost the structure of a zona glomerulosa, and contains a zona fasciculata reaching up to the aforementioned cell balls (figs. 9). In preparations in which the separating fibrils are not stained, the layer of newly formed cell balls might, at this stage, appear to be the zona glomerulosa. The transformation of the old zona glomerulosa has already begun during the formation of cortical cell plates in the capsule (fig. 8). In figure 7, a stage is shown in which the cell balls of figure 6 have connected with the old cortex, and present a typical zona glomerulosa. Intermediate stages in which the dividing layer of lattice fibers is partly preserved, may readily be found in many adrenals. It can be seen constantly that the transformation of the old zona glomerulosa into part of the zona fasciculata is closely correlated with the appearance of cortical cell plates in the capsule, and their transformation into a new zona glomerulosa. In contrast to the mechanism described by Zwemer, Wotton and Norkus (and also illustrated by the present figures 17 and 18), one finds in the guinea pig that a new formation of an entire layer of cortical tissue becomes secondarily apposed to the old cortex and replaces the zona glomerulosa over an area covering many cortical cords. Differentiation of cortical tissue in the capsule is not always limited to a layer three or four cells thick as shown in the present figures. If a thicker layer is formed, it breaks up into irregular cords of roughly radial arrangement rather than spherical cell balls, and this mass of cords is for some time separated from the old cortex by lattice fibers just as the cell balls in figure 6. The persistence of the fibers separating new and old cortical tissue, shows considerable variation. In some instances the fiber network is perforated in an early stage while the new layer is still an undivided plate, and in other cases the newly differentiated tissue is completely divided into individual units of the future zona glomerulosa before connections with the old cortex penetrate the lattice fiber layer. No information is available as to the cause of this variability. One might suspect that a rapidly developing new layer can reach a far advanced stage before attachment to the underlying cortex occurs.

Unilateral adrenectomy in guinea pigs did not produce significant changes in the capsule and zona glomerulosa of the remaining adrenal over periods ranging from 6 hours to 17 days after the operation. The same mosaic of various stages of apposition is seen as in normal animals. The probable reason for this absence of significant changes will be given later, in the discussion of the results.

Dog

The zona glomerulosa in the dog's adrenal is very conspicuous, and consists of large epithelial arches with their convexities toward the capsule. In many adrenals, sections show no indication of formation of cortical cells in the capsule, while in others, cortical cell groups of varying number and size may be seen. In the present material, one adrenal was conspicuous for its unusually large number of these foci (fig. 10). Small cortical cell groups are often found in the capsule, without connection with the rest of the cortex. The larger ones are divided into several cell cords, and are no longer separated from the zona glomerulosa. It seems that these cell groups extend toward the adrenal as they grow. At the same time their structure resembles more and more that of the zona glomerulosa. As in the guinea pig, the zona glomerulosa itself is gradually reduced under these foci, and when extensive connections with the new cords are established, the old zona glomerulosa and these cords together are about as thick as the fully developed zona glomerulosa in other parts of the same organ (fig. 11). Here, again, areas of the zona glomerulosa are replaced by groups of newly formed cords which move into their new position as a compact layer. The changes are not as regular, and do not occur as frequently as in the guinea pig, but the process is essentially the same in both species.

Cat

The material at our disposal allowed the study of the adrenals of immature as well as adult animals. Wotton and Zwemer ('43) have stated that new formation of cortical tissue in the capsule is more extensive in kittens than in mature cats, and our own material shows, in accordance with this statement, a considerable difference between these two age groups. In kittens of a few days or weeks of age, two definite layers may be seen in the adrenal capsule. The outer one is rich in collagenous fibers, and its cells are those of typical connective tissue. The inner layer, bordering on the cortex, is poor in fibers and its cells are more numerous, larger, and have large pale nuclei. This tissue is, in places, similar to the cortex itself, and shows fluent transitions to typical cortical tissue (fig. 12). It is highly probable that this entire mass is transformed into cortical cells during the first few months of postnatal life. Silver impregnation reveals in some instances a complete loss of lattice fibers within this inner portion of the capsule as well as between it and the cortex proper (fig. 13). The condition in these kittens recalls the suggestion of Bachmann (derived from the study of a human adrenal) that a subcapsular blastema rather than the capsule itself, gives rise to the new cortical tissue. Figures 12 and 13 show the difficulty involved in determining the exact manner in which these newly differentiated cells join the adrenal proper, because of the scarcity of fibers outlining the cords. However, it is apparent that the entire inner layer of the capsule (or subcapsular blastema) is transformed into cortical tissue within a relatively short period of time, and this alone is sufficient to permit the assumption here, as in the guinea pig and dog, of the apposition of a continuous layer. The only areas where end-to-end junction of old and new cortical cords may be seen, are found where the capsule projects into the gland as, for instance, around the central vein. Here the fibers of the capsule radiate obliquely into the gland, and it seems that this determines a similar course of the cortical cords (fig. 14).

No remnants of the cellular inner layer of the capsule have been found in any of the adult cats. The zona glomerulosa now borders directly on a capsule with very densely arranged collagenous fibers. In agreement with a statement of Bennett, no pictures could be seen suggesting the differentiation of cortical cells in the adrenal capsule of these adult cats. However, the arrangement of the cell groups in the zona glomerulosa shows in many areas a curious similarity with stages of the incorporation of newly formed cortical cell layers in the guinea pig. Figure 15 shows an area, larger than it was ever seen in a guinea pig adrenal, where a continuous layer of argyrophil fibers separates cell balls of approximately spherical shape from the deeper parts of the cortex. The similarity with figure 6 of a guinea pig adrenal is striking. Pictures suggesting perforation of this lattice fiber layer, and junction of the cell balls with deeper cords, are also common in the cat adrenal (fig. 16, corresponding to fig. 7 of the guinea pig). In other instances, very small areas at the periphery of the cortex corresponding perhaps to single cells, are bounded by lattice fibers. No interpretation of these findings can be given at the present time. The absence of early phases of new formation in the capsule precludes the assumption of complete analogy with the guinea pig.

Rhesus monkey

The rhesus monkey, and with some limitations also man, are examples of species with an inconspicuous zona glomerulosa. The cords of this layer are continuations of fasciculata cords and are little or not at all wider than the latter. Their arrangement is very regular in the rhesus monkey. In many areas where the cords are cut longitudinally, they are seen traversing the zona glomerulosa obliquely, and parallel to each other. Their distal ends project slightly between the collagenous fiber bundles of the capsule (fig. 17), and it is easy to understand that new cords differentiating within the capsule can join the ends of the old cortical cords (Zwemer, Wotton and Norkus). A low-power view of the arrangement of the cortical cords (fig. 18) shows not only their oblique course, but also their junctions with a few apparently newly formed cords which are located in the capsule, and parallel to the surface. Only two rhesus adrenals were available for examination, and in these no indication of replacement of cortical tissue by complete layers (as in the guinea pig or dog) was seen.

Man

In many human adrenals one finds conditions similar to those just described in the rhesus monkey. However, the cords in large parts of the zona glomerulosa are not quite as regularly arranged as in the monkey, and considerably thicker than in the zona fasciculata so that a more conspicuous zona glomerulosa may be seen. In other areas of the zona glomerulosa, cords not thicker than in the zona fasciculata extend obliquely to the capsule, and are often connected with obviously new cords within the capsule itself. Figures illustrating this condition were previously published (Gruenwald, '42; figs. 14 and 15). The description of Zwemer, Wotton and Norkus covers these forms as well as those described in the rhesus monkey. Bachmann objected to the concept of these authors in a publication without illustrations, and based on tangential sections of one human adrenal. In his opinion, new cortical cords differentiate not in the capsule but in a subcapsular blastema. As was mentioned above in the description of adrenals of immature cats, a highly cellular inner layer of the capsule may occasionally be present and could be called a subcapsular blastema. This, however, is by no means the rule. Particularly in human adrenals newly formed cortical cords are often found interspersed between the collagenous fibers of the otherwise uniform capsule. Figure 19 shows an example in which cortical cords are present in all levels of the capsule including its outer border. There is no indication of a subcapsular blastema in the human adrenal.

In some human adrenals cortical cords form in large numbers in the capsule and accumulate there, leaving intact large portions of the layer of collagenous fibers which separates them from the zona glomerulosa (fig. 20). These groups of cords grow until they form a layer of considerable thickness on the surface of the organ, as shown in two stages in figures 21 and 22. The underlying cortex meanwhile loses its zona glomerulosa, apparently by transformation into part of the zona fasciulata, and it becomes evident that the new layer on the surface has taken the place of the outer part of the cortex while it is still separated from the rest of the organ by a definite layer of collagenous fibers. This fiber layer may extend over considerable parts of the adrenal, and it is perforated in some places by blood vessels and cortical cords. No observations are available concerning its ultimate fate, but it can be assumed that it finally disappears. Figure 22 shows the deepest position in which it was found in our material. It is thus apparent that replacement of cortical cells from the capsule occurs in the human adrenal not only by the mechanism of end-to-end junction of single new and old cords at the outer border of the cortex, but also by apposition of large masses of cords forming a distinctly separate layer long after their differentiation into cortical tissue. This latter process resembles the observation in the adrenals of guinea pigs and dogs as described in the preceding sections of this report. As was pointed out in the description of guinea pig adrenals, we do not know definitely what causes the fiber layer between new and old cords to persist in some cases longer than in others. It is obvious that in man formation of a continuous new layer of cortical tissue occurs only when large amounts of this tissue are differentiating at the same time, while scattered cords will attach themselves individually to the peripheral free ends of old cords in the zona glomerulosa. One must also be prepared to find intermediate forms when small groups of cords join the zona glomerulosa. From the functional point of view one might wonder whether the presence of an almost uninterrupted layer of collagenous fibers does not interfere with the abundant circulation which usually passes through long radial capillaries between the cords. Another open question is the speed with which a new layer of cortical tissue grows, and the connective tissue layer is pushed inward. The few available cases have not permitted a correlation of the width of the new layer with the time elapsed since some dramatic event in the history of the individual (as revealed by the hospital record). Systematic study of a large number of cases may allow the recognition of a correlation of this kind.

Other mammals

Rabbit. The zona glomerosa of the rabbit adrenal shows definite epithelial arches, although not as conspicuous as in the dog. In none of the adrenals, including those preserved after unilateral adrenectomy, could any indications of new formation of cortical tissue be discovered in the capsule. The material at hand is not large enough to allow the definite statement that no such new formation ever occurs in the rabbit. However, we may say that changes comparable to those described in the preceding sections, do not occur frequently in that animal.

Rat. Only a few specimens were available. Various histological methods show very thin cell cords, and an indistinct separation of the zones in the cortex. No definite indications of apposition from the capsule are present in the few available sections. Some cells of the capsule have slightly increased amounts of cytpolasm, but they were not seen to form cords or solid layers.

Pig. Sections of one adrenal reveal a zona glomerulosa with cords definitely thicker than in the zona fasciculata, but without extensive arch formation. Small masses of cortical tissue are present in several parts of the capsule, and join the underlying cortex in a similar manner as described above for the dog.

Horse. The one organ at our disposition was previously described by Gruenwald ('42). A very broad zona glomerulosa is present, more definite even than in the dog. The majority of the cords form large arches, but some of them appear to end freely beneath the capsule (although this cannot be stated with certainty in the absence of reconstructions). This would make possible both of the above described types of apposition. A few compact masses of cortical cells are present in the capsule, and may be seen to connect with the zona glomerulosa in a manner resembling the conditions in the dog. One of these areas with beginning junction was previously shown in a photograph (Gruenwald, '42, fig. 11).

The great variability in the structure of the zona glomerulosa in mammals suggests that the number of mechanisms of junction between new and old cortical tissue may not be limited to the two described in the present report. Study of additional material may well reveal new variations of these two types of apposition, or entirely different types.

Embryonic adrenals

Only scattered observations can be reported concerning embryonic stages of the structures under consideration, that is, the zona glomerulosa and adjoining levels. The early embryonic adrenal cortex is non-epithelial: each cell is surrounded by a network of lattice fibers (Gruenwald). The epithelial zona glomerulosa appears later by a structural change in the peripheral layers of cortical cells. With the customary staining methods it can then be distinguished from the remaining portions of the cortex by its much smaller cells. Coincident with the appearance of this difference in cell size is a disappearance of the lattice fibers within the cords of the zona glomerulosa (fig. 23). This fact as well as the outlines of the cords themselves can best be visualized by silver impregnation. The usual methods will not show the arrangement of the cells of this zone in cords, but just a continuous cell mass. The zona glomerulosa appears relatively late in the development of the organ, in human embryos of the fourth month, and in cat embryos of more than 70 mm. Not in all instances is this layer distinctly bounded against the capsule; this suggests that transitions may occur here, but not by formation of definite cords as in adult animals, so that the mechanism cannot be followed in detail by the study of sections. The very early zona glomerulosa may show no subdivision in cords, and thus resemble the condition shown in figure 13 in a kitten by the presence of a continuous layer of cortical tissue. This was seen in cat and pig embryos. Just what role the appearance of cavities in the zona glomerulosa of human (and some other) embryos plays in the shaping of the structural units of this layer (Hett), cannot be decided. The final result is essentially similar in species with and without cavities in their embryonic zona glomerulosa.

One observation in embryonic cattle adrenals should be briefly described although its significance is not clear. A very extensive zona glomerulosa is formed in these embryos, consisting of large branched cords with considerable amounts of connective tissue between them. In late embryos[1] this zone is separated from the underlying part of the cortex by a layer of connective tissue which is uninterrupted in large areas (fig. 24), thus separating the two layers of the cortex except for a few scattered cords which perforate the connective tissue. No sufficiently late stages are available to study the further development of this separated zona glomerulosa. In this particular instance the existence of an outer layer of cortex bounded proximally by connective tissue, is not the expression of apposition of large masses of new cortical tissue since the separation appears secondarily.

DISCUSSION AND CONCLUSIONS

The study of cell replacement from the capsule in the adrenals of several mammalian species has shown that great differences exist not only between species, but also between various periods in the life of one species. The latter is exemplified by descriptions of adrenals of immature and adult cats. It is essential to study each species before anything can be said about its particular mechanism of cell replacement from the capsule. Even closely related animals may show differences great enough to preclude the application of results obtained in one of them to related kinds. In spite of this great variety of forms, two mechanisms can be distinguished which explain the incorporation of newly formed cortical tissue into the cortex itself in all forms studied until now. One of these has been adequately described by Zwemer, Wotton and Norkus, and consists of end-to-end junction of each of the new cords with an old one extending obliquely through the zona glomerulosa toward the capsule. The newly formed cords apparently move in the direction of their long axis in order to become part of the zona glomerulosa (fig. 1). It is obvious that only certain types of zona glomerulosa lend themselves to this kind of apposition, namely, those in which the cords are mere distal continuations of the fasciculata cords, with free ends at the border of the capsule. This occurs in the adrenals of man and the rhesus monkey and, to a limited extent, in those regions of other adrenals where the capsule protrudes into the organ either alone or as a cover of blood vessels (fig. 14). However, even in human adrenals this is not the only mechanism of appositional growth or replacement of the cortex. If large numbers of cords are formed simultaneously in the capsule, they form solid masses of cortical tissue and join the cortex without at first connecting individually with glomerulosa cords.

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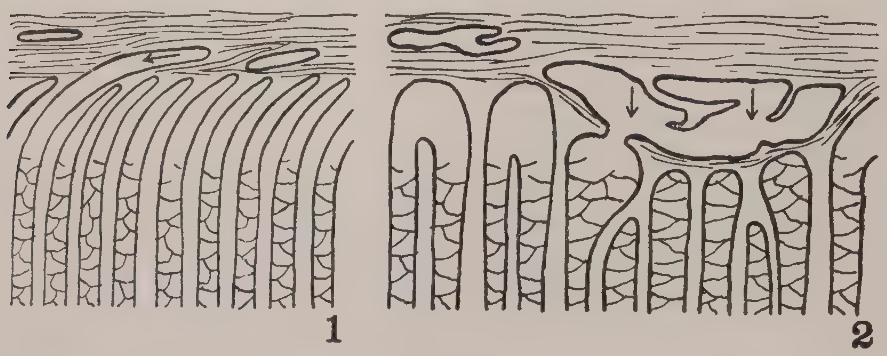
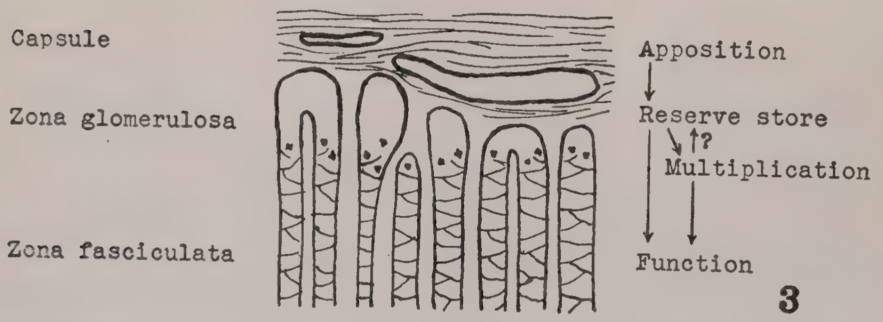
[1] Through an unfortunate accident the measurements of all but one of the seven specimens were lost. The smallest and apparently youngest adrenal is that of a 16-cm. embryo. The others are considerably larger and farther advanced in development, and the largest one described here must be that of a rather late embryo.

This apposition of a solid layer characterizes the second type of replacement, and is typical of those adrenals which have a zona glomerulosa with wide arches, and no free ends of cords to connect with newly formed cortical tissue in the capsule (fig. 2). In this second type of replacement the tissue moves not in the direction of the long axis of individual cords, but perpendicular to the surface of the organ (compare figs. 1 and 2). The layer laid down on the surface of the cortex may consist of a single plate of tissue, as is often found in the guinea pig (fig. 5), or of groups of small cords as seen in the dog (fig. 11). Its connection with the cortex may occur at various stages of its differentiation. In some instances the new layer has replaced the entire zona glomerulosa in that particular area, and assumed its histological characteristics before it fuses with the peripheral parts of the old cortex, now transformed entirely into fasciculata cords. In these cases of late junction a definite layer of collagenous or lattice fibers may persist for a long time between old and new cortical tissue, and is then found surprisingly deep in the cortex. In other instances (in the same species) the new layer joins the old zona glomerulosa before the latter is transformed into part of the zona fasciculata. In the presence of a thick layer of new cortex the old zona glomerulosa disappears more completely: this will happen if the new layer is as thick as the normal zona glomerulosa, and replaces it entirely. Thus, the presence of collagenous fibers deep in the cortex, under a thick newly formed layer, is probably to be regarded as an indication of extensive replacement.





Figs. 1 and 2 Diagrams of the incorporation of newly formed cortico-adrenal tissue in the zona glomerulosa: end-to-end junction of newly formed cords and those of the zona glomerulosa (fig. 1), or replacement of the old zona glomerulosa by newly differentiated cortical tissue (fig. 2). The tissues are shown roughly as they would appear after impregnation of the reticulum fibers: parallel fibers in the capsule, and fiber networks separating the cells within the fasciculata cords, but not within the zona glomerulosa and the newly formed cortical tissue. Arrows indicate the direction in which the new tissue moves to join the adrenal cortex.

Fig. 3 Diagram illustrating the proposed hypothesis of cell replacement in the adrenal cortex, drawn as figures 1 and 2. The dots at the border of zona glomerulosa and fasciculata indicate the site of mitotic division of cortical cells.

It may also suggest rapid new formation, leaving no time for disappearance of the collagenous fibers until considerable differentiation and growth of the new layer has taken place.

It may not always be possible to draw a definite line between the two mechanisms of cortex replacement, particularly in those species in which both kinds occur. Difficulties in this classification may appear if small groups of cords join the cortex, or in regions in which the surface of the cortex does not show its typical structure due to bends or invaginations of the capsule. Various factors may be thought to influence the manner of incorporation in the cortex in the direction of one or the other of these mechanisms. The structure of the zona glomerulosa has already been mentioned as one of these factors, and observations in human adrenals suggest that the amount of newly formed tissue may be another one. Single cords will tend to follow the first mentioned type, and large masses the second one. This question, as well as many others which have suggested themselves in the course of this study, will be solved only by experiments or pathological observations in which time and intensity of the stimulus for replacement are known. Finally, one must remember that mechanisms of apposition other than the two described here, may be in existence in species not thoroughly studied as yet.

We know from a number of investigations reported in the literature that differentiation in the capsule is not the only means by which cortical cells can be replaced. The absence of apposition from the capsule in many adrenals indicates that in these instances a sufficient supply of new cells is available for the zona fasciculata where, according to all reports, the specific function of the cortical cells occurs. This supply comes from the periphery either by mitotic division, or by mobilization of cells from the zona glomerulosa. It was repeatedly shown in the present report that this zone may be taken up entirely into the zona fasciculata, and is then replaced by apposition from the capsule.

The stages through which a cortical cell passes from its differentiation in the capsule to its degeneration in the zona reticularis, have been described and presented in a diagram by Zwemer, Wotton and Norkus ('38, fig. 1). The various phases of this process are accompanied by characteristic changes in arrangement and mutual relation of the cells, as briefly described by Gruenwald ('42). Immediately after their differentiation from capsular "fibroblast-like" elements (Zwemer, Wotton and Norkus), these cells assume an epithelial arrangement in cords or other solid masses as described above, with no fibers or other intercellular substance separating them from adjoining cells in the same cord. After moving through the zona glomerulosa into the fasciculata, they again lose their epithelial relations to each other, as is evident from the appearance of lattice fibers surrounding each cell within the cord. This change to and from epithelial arrangement is a common characteristic of tissues derived from the coelomic wall and its mesothelium (Gruenwald, '42).

The present considerations lead to the following tentative concept of the mechanism of replacement of functioning cells in the adrenal cortex (fig. 3). A moderate demand for functional cortical cells is taken care of by mitoses at the upper border of the zona fasciculata. If the demand is increased, cells stored in the zona glomerulosa are mobilized and move down with or without division. This is probably of great importance in those instances in which rapid replacement and function are necessary, because glomerulosa cells are available without cell division. We know that cells in mitosis cannot discharge their specific function and vice versa, and that mitoses are often absent in the early phases of regeneration. Whether or not the reserve store in the zona glomerulosa can later be replenished by mitoses at its proximal border (fig. 3, arrow with question mark), is not known. It appears, however, that extensive depletion of the zona glomerulosa is followed by formation of a new zone from the capsule. It is thus easy to understand that those species which have a poorly developed zona glomerulosa, show abundant evidence of apposition from the capsule almost in every organ (human adrenals), while others with a large zona glomerulosa show these changes rarely, apparently because their reserve stores of cortical cells are not so frequently exhausted. Differentiation of cortical tissue in the capsule would then be an indication of exhaustion of the stores of cells by past demand rather than of immediate need for functional cells. How soon the newly differentiated cells are to reach the functional phase, depends on future demands on the newly formed zona glomerulosa.

This indirect effect of cell demand on the process of apposition from the capsule probably explains the failure of our experiments with unilateral adrenectomy to show definite effects in the capsule of the remaining adrenal. The hypertrophy induced by removal of the contralateral organ affected the capsule only, or predominantly in those areas in which the zona glomerulosa was depleted. Thus the effect on various parts of the organ varied according to the stage of cell storage in the zona glomerulosa, and the expected provocation of immediate and uniform differentiation in the entire capsule did not occur. Similarly, the evaluation of capsular changes in experiments or in pathological specimens will be difficult because the effect of any stimulation of cell replacement on the capsule is probably an indirect and delayed one, and depends largely on the unknown condition of each point of the zona glomerulosa at the time of stimulation. In agreement with this postulate is a statement of Zwemer to the effect that stimulation of a short duration may not affect differentiation in the capsule even if it is of great intensity.

In spite of this difficulty it will be necessary to learn how to correlate findings of apposition of cortical tissue from the capsule with other morphological and physiological observations in order to obtain a complete picture of the function of the adrenal cortex in a given instance. In our studies concerning only one factor, namely, apposition, it was necessary to combine observations in sections with azan or a similar stain with the results of silver impregnation. These two methods should be used until extensive experience with a particular species may enable an investigator to dispose of one of them. Needless to say that this type of examination of the adrenal cortex in no way replaces others such as, for instance, demonstration of lipoids in the cells.

In human pathology one should endeavor to correlate findings of apposition, and particularly such extensive changes as shown here in figures 19 to 22, with the condition of the individual shortly before death. Attempts to do this in the small number of cases at our disposition were unsuccessful. A very large material with accurate clinical histories will be necessary to obtain significant results. Zwemer claims to have found such correlation of his histological findings in the adrenal cortex with pathological and clinical conditions in 200 cases, but he does not amplify his statement by any data on the conditions encountered and the criteria by which the demand on the adrenal cortex was estimated. If our concept is correct, human or monkey adrenals must be good subjects for these studies; their poorly developed zona glomerulosa is not able to supply many cells so that any demand should rapidly and extensively affect differentiation in the capsule.

SUMMARY

A study of apposition of newly differentiated cortico-adrenal tissue from the capsule in various mammals reveals that two mechanisms exist by which this tissue attaches itself to the cortex. One of these has previously been described by Zwemer and coworkers and consists of end-to-end junction of newly formed cords with those of the cortex. The other mechanism is one of apposition of a complete new layer which finally replaces the old zona glomerulosa in a larger area of the adrenal surface. The occurrence of one or the other of these processes depends on the shape of the glomerulosa cords in the particular species, and on the amount of newly formed tissue. Large arches in the zona glomerulosa, and great amounts of newly differentiated tissue favor

the replacement by complete layers, but both types of apposition may occur in the same species as, for instance, in man.

A hypothesis is proposed according to which the replacement of functioning cortical cells takes place by three mechanisms:

1. Mitotic division at the junction of zona glomerulosa and fasciculata.
2. Mobilization of cells from a reserve store represented by the zona glomerulosa.
3. Replacement of depleted stores by apposition from the capsule.

It is consistent with this hypothesis that adrenals with a large zona glomerulosa show signs of apposition less frequently than those in which the zona glomerulosa is poorly developed. The influence of demand for cortical cells on differentiation in the capsule is probably an indirect one, through depletion of the zona glomerulosa.

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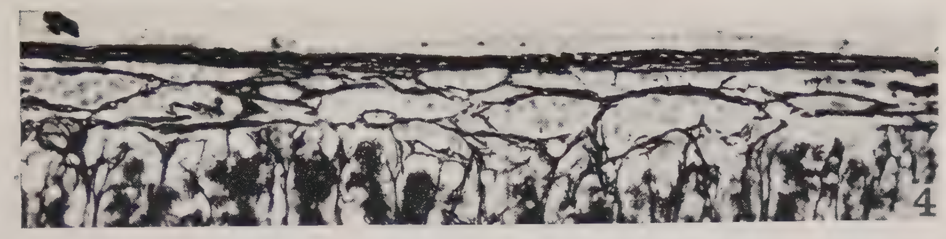
PLATE 1

EXPLANATION OF FIGURES

Sections of normal guinea pig adrenals

4–7 Four stages of the incorporation of newly formed cortical tissue in the adrenal cortex showing, respectively, thin cortical cell plates in the capsule, thick plates in the capsule, thick plates breaking up into cell balls, and new zona glomerulosa formed by these cell balls. Gomori's silver impregnation and acid alizarin blue.

8 and 9 Azan-stained sections corresponding to figures 5 and 6, respectively.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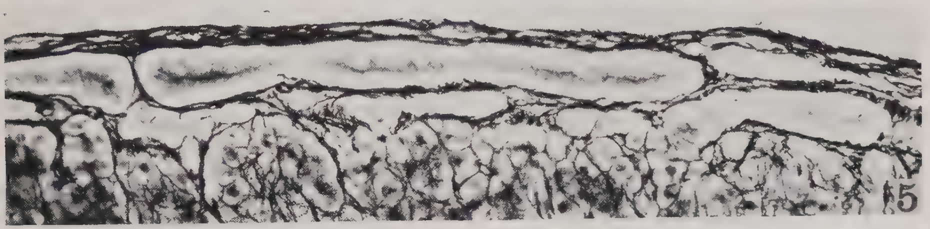
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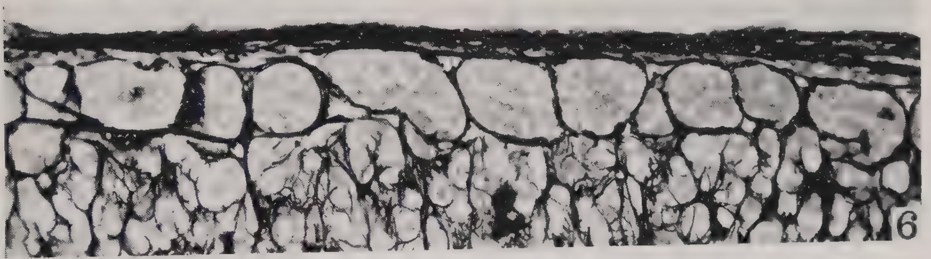
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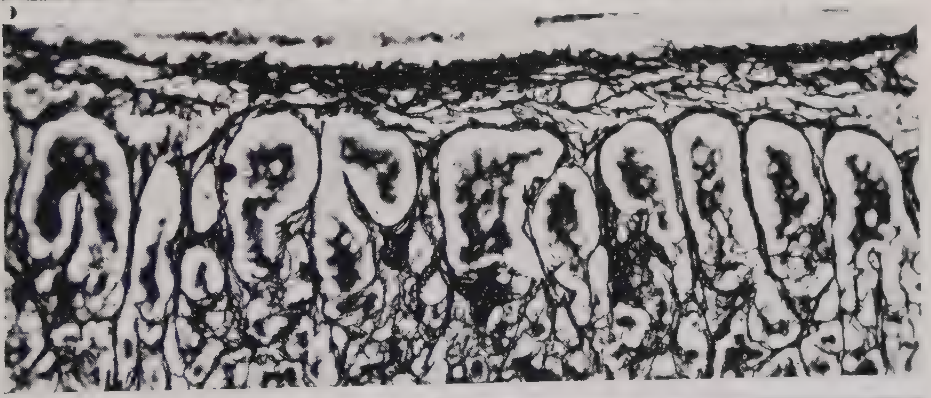
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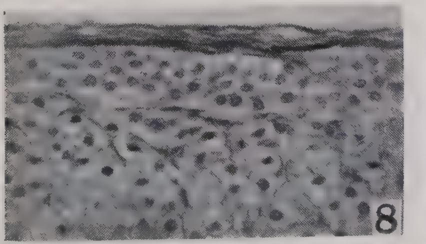
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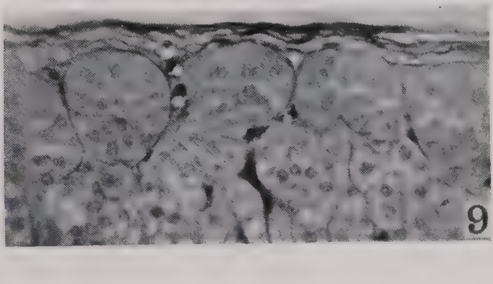
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PLATE 2

EXPLANATION OF FIGURES

10 Dog adrenal. Numerous areas of cortical differentiation in the capsule are indicated by arrows. Azan stain.

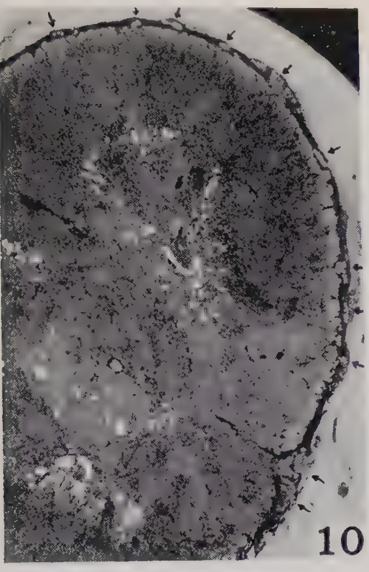
11 Dog adrenal. Newly formed cortical tissue in the process of joining the zōna glomerulosa. It is still separated from the older cortex by collageneous fibers. New cortical tissue and zona glomerulosa under it are about as thick as the zona glomerulosa alone in other parts. Azan stain.

12 Five-day-old kitten. I, inner and O, outer layer of the adrenal capsule. Azan stain.

13 Fourteen-day-old kitten. I, inner layer of the adrenal capsule (or newly differentiated cortical tissue?). Gomori's silver impregnation.

14 Five-day-old kitten. Adrenal surface near the central vein. Fibers of the capsule radiate obliquely into the cortex. Gomori's silver impregnation. Azan stain.

15 and 16 Adrenals of adult cats. The outlines of cell groups in the zona glomerulosa resemble those of the guinea pig (figs. 6 and 7). Gomori's silver impregnation.



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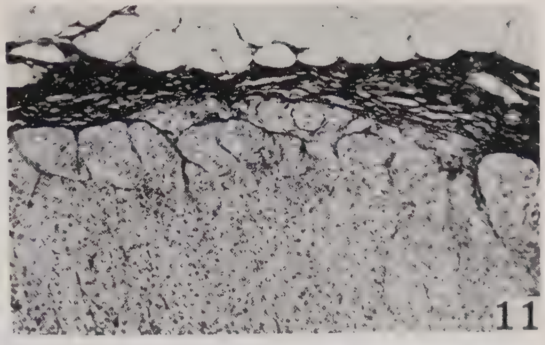

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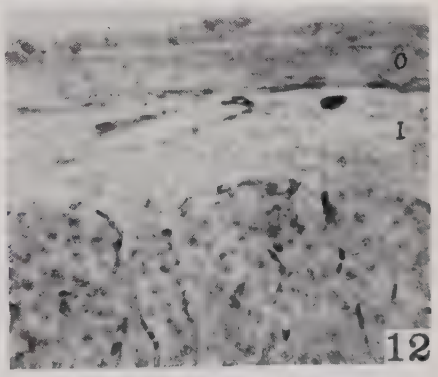

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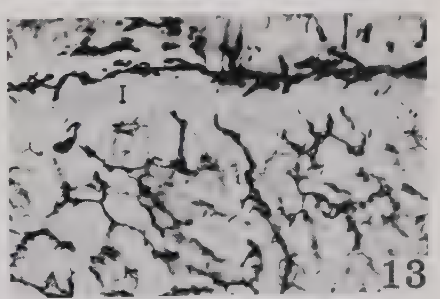

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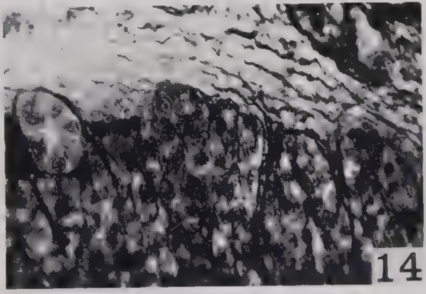

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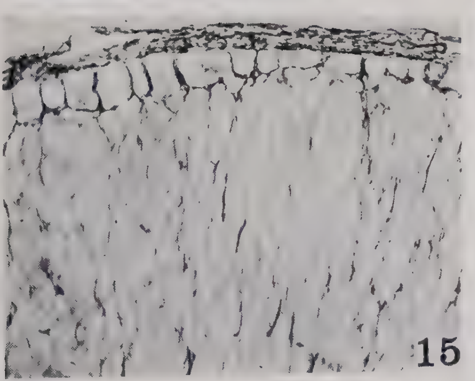

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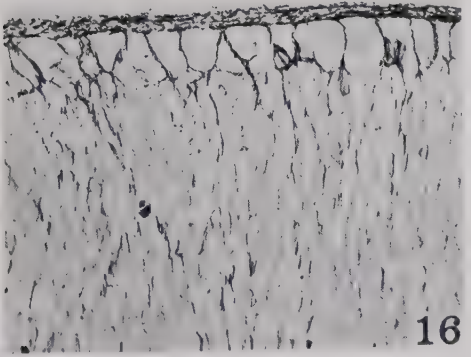

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PLATE 3

EXPLANATION OF FIGURES

17 Adrenal of a rhesus monkey. The zona glomerulosa consists of slender cell cords directed obliquely toward the capsule. Azan stain.

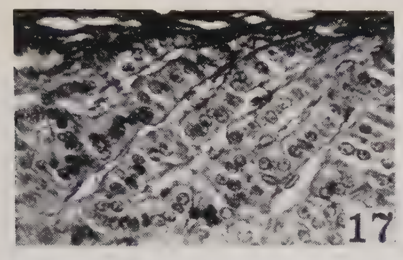
18 Adrenal of a rhesus monkey. The oblique cords of the zona glomerulosa are shown with low magnification. They join with apparently new cords extending parallel to the surface of the organ (arrows). Gomori's silver impregnation and acid alizarin blue.

19 Human adrenal with numerous newly differentiated cortical cell cords throughout the capsule. Azan stain.

20–22 Human adrenals with increasingly thick layers of apparently newly formed cortical tissue, separated from the older cortex by collagenous connective tissue. Azan stain.

23 Adrenal of an 85-mm. dog embryo. The cords of the zona glomerulosa (G) begin to differ from the rest of the cortex by the lack of argyrophil fibers between their cells. Gomori's silver impregnation.

24 Adrenal of a cattle embryo. G, zona glomerulosa; C, rest of the cortex; M, medulla. Gomori's silver impregnation.



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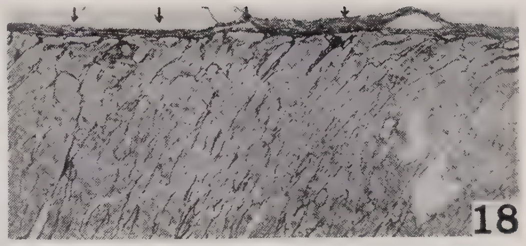

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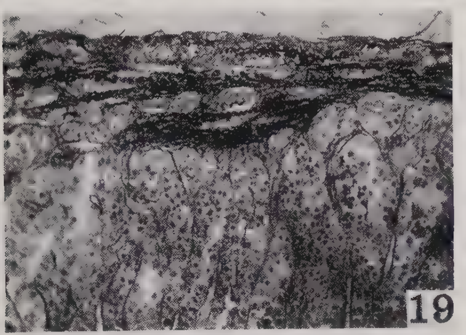

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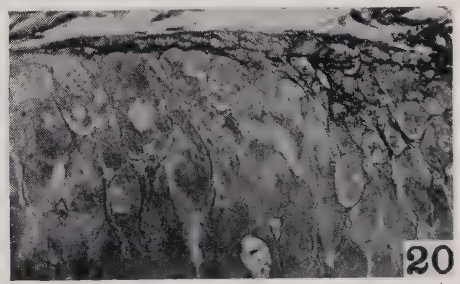

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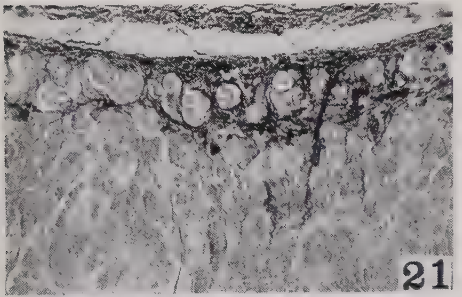

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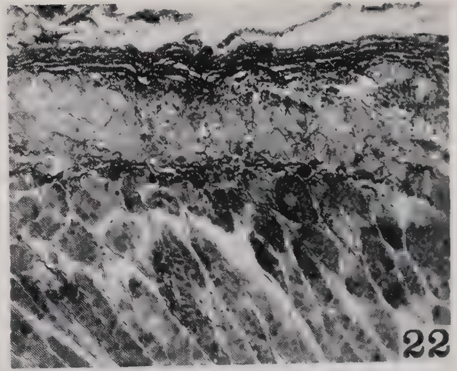

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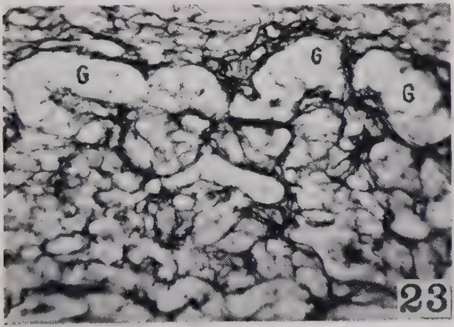

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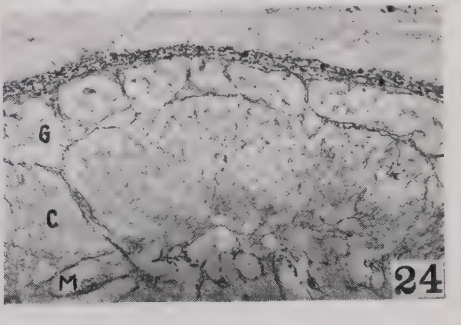

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A COMPARATIVE STUDY OF THE CLAVICULAR LIGAMENTS OF THE RAT, RABBIT, CAT, AND DOG

CARL J. SANDSTROM AND ABRAHAM SALTZMAN
Department of Biology, University College, New York University

SIX FIGURES

Excepting for the shoulder ligaments of man, the clavicular ligaments of mammals have received only slight attention. Generally such observations as have been reported deal only with their anatomy, and omit consideration of their possible role in the functional activity of the girdle. Straus-Dürckheim (1845) described the ligaments of the shoulder of the cat, and compared them with those of man. His observations on the cat, however, were not entirely correct. Parker (1868), in his monograph on the structure of the shoulder girdle in vertebrates, frequently mentioned the various clavicular ligaments in his descriptions, and often depicted them in his illustrations although in certain instances either incompletely or inaccurately. In no other publication has a comparative study been approached, albeit Liberson ('39), interested primarily in the coracoclavicular ligament of man, gave some thought to the evolutionary origin of these structures. Weber ('27) occasionally referred to them, especially when describing the relations of the clavicle to the scapula and sternum in those forms where the clavicle is reduced.

The importance of the clavicular ligaments in the proper functioning of the pectoral girdle has never been adequately considered save in man where the investigations have resulted in numerous reports dealing primarily with clinical observations and corrective devices, e.g., Liberson (loc. cit.), Bosworth ('41), and others. These writers consistently stressed the fact that proper functioning of the arm and shoulder is dependent on the ligaments, but especially noteworthy were the observations of Liberson on the mechanism of the coracoclavicular ligament in the normal movement of the scapula. He was able to demonstrate convincingly how particularly well the conoid and trapezoid ligaments, comprising the coracoclavicular in man, are adapted to the needs of the human. They serve in stabilizing the scapula to the clavicle by checking the relative amount of movement between these structures, and it is through them, to a large extent, that the forces of lifting, etc., are transmitted, via the clavicle, to the sternum. In order to function properly in this regard, a ligament must be taut, and in the human the parts under consideration are so arranged that, regardless of the position of the arm or scapula, at least one of two is always in this condition. Injuries to either will, if not properly repaired, cause considerable discomfort, and partial impairment of the activity of the arm, a fact which emphasizes their importance.

The almost complete disregard in the literature dealing with syndesmology of the clavicular ligaments for all forms other than the human, coupled with the possibility that they might be significant functional components of the pectoral girdle, suggested that it would be appropriate to give them further consideration, especially in those forms wherein the articulation of the clavicle with the sternum and scapula are not as complete as in man. Such an investigation, besides adding to our knowledge of the anatomy, and perhaps functioning, of the shoulder, might, if extended, lead to information of phylogenetic significance. Accordingly, careful observations were made on the three primary clavicular ligaments, viz., the acromioclavicular, the coracoclavicular and the sternoclavicular, in the rat, rabbit, cat and dog, and brief consideration was also given to the already familiar conditions present in the human. The results have previously been reported in abstract by Sandstrom and Saltzman ('40).

Diagrams to show the relations of the primary clavicular ligaments to the clavicle, scapula, and sternum. All are dorsal aspects, with some slight displacements which were necessary in order to show attachments of ligaments, etc.

Fig. 1 Human. × ⅕.
Fig. 2 Rat. × 2.
Fig. 3 Rabbit. × ½.
Fig. 4 Cat. × ½.
Fig. 5 Dog. × ½.

Fig. 6 A series of diagrams to illustrate the flexibility of the sternoclavicular articulation in the rat:

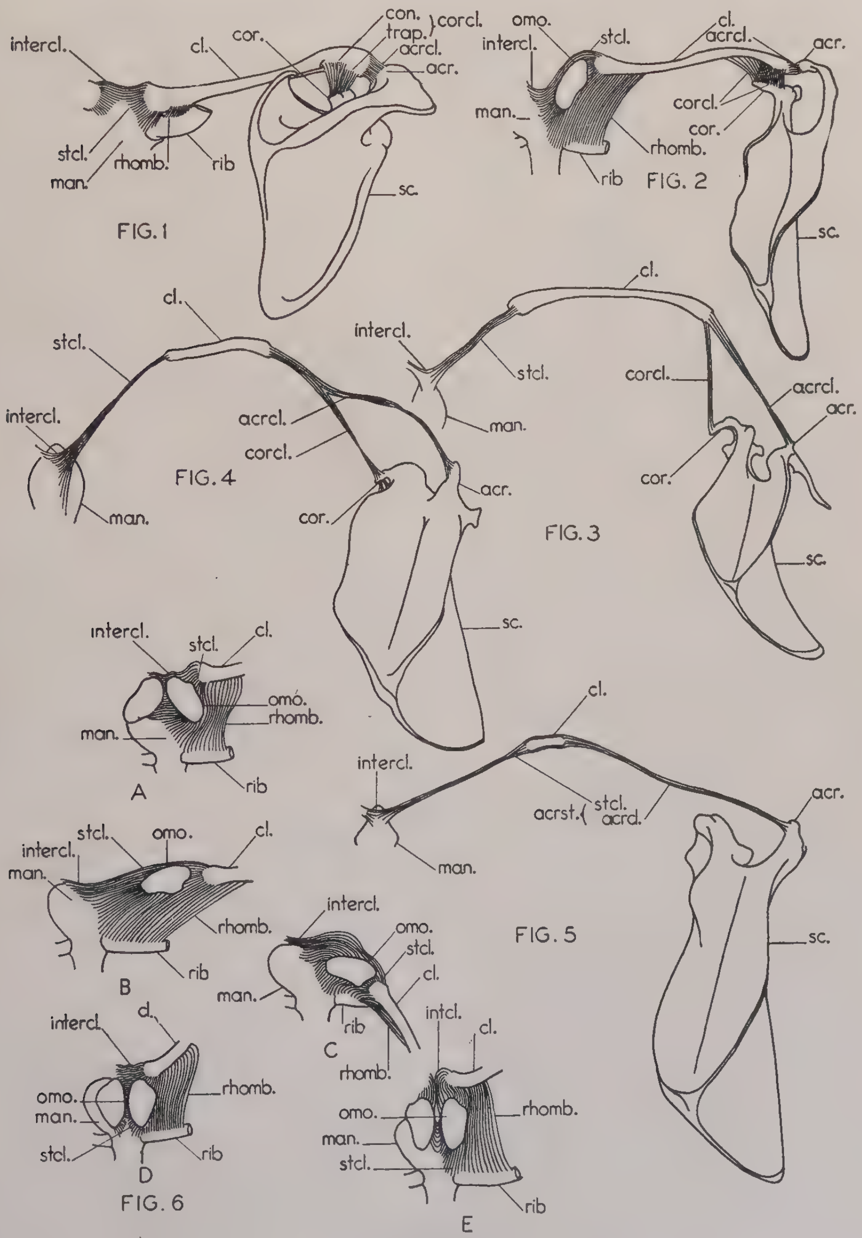
A — arm pulled medially; B — arm stretched laterally; C — arm pulled caudally; D — moderate elevation of the shoulder; E — high elevation of the shoulder.

ABBREVIATIONS

acr., acromion process
acrcl., acromioclavicular ligament
acrst., acromiosternal ligament
cl., clavicle
con., conoid ligament
cor., coracoid process
corcl., coracoclavicular ligament
intercl., interclavicular ligament
man., manubrium
omo., omosternum
rhomb., rhomboid ligament
sc., scapula
stcl., sternoclavicular ligament
rib, first rib
trap., trapezoid ligament

THE RAT (fig. 2)

Of the four mammals studied, the rat alone has a well formed clavicular brace and, with the associated ligaments, possesses a shoulder mechanism comparable to that of the human (cf. fig. 1).


intercl.
cl.
cor.
con.
trap.
corcl.
acrcl.
acr.
stcl.
man.
rhomb.
rib
sc.
FIG. 1
omo.
intercl.
stcl.
cl.
acrcl.
acr.
man.
corcl.
cor.
rhomb.
rib
FIG. 2
sc.
cl.
intercl.
stcl.
corcl.
acrcl.
acr.
man.
cor.
FIG. 3
sc.
cl.
stcl.
intercl.
acrcl.
corcl.
FIG. 4
man.
cor.
acr.
sc.
intercl.
stcl.
cl.
omo.
rhomb.
man.
rib
A
cl.
intercl.
acrst.
stcl.
acrcl.
acr.
man.
sc.
FIG. 5
stcl.
omo.
cl.
intercl.
man.
rhomb.
rib
B
intercl.
omo.
stcl.
cl.
man.
rib
C
rhomb.
intercl
cl.
rhomb.
omo.
man.
stcl.
rib
D
FIG. 6
intcl.
cl.
omo.
rhomb.
man.
stcl.
rib
E

Figures 1 to 6

Acromioclavicular ligament. The acromioclavicular ligament is capsular as in man. It retains the articulation between the elongated anteriorly projecting acromial process of the scapular spine and the lateral tip of the clavicle which bears an articulating facet. The acromioclavicular articulation permits considerable movement, and the ligament, although relatively small, is nevertheless very strong. It is best developed on the dorsal side, whereas in the human, the inferior and superior parts are especially strong.

Coracoclavicular ligament. The coracoclavicular ligament is a tough, relatively broad, trapezoid-shaped band measuring approximately 3 × 7 mm. It extends anterolaterally from the dorsal surface of the coracoid process to attach to the lateral fifth of the clavicle. Histologically, it consists of two parts. The primary portion is made up of the usual white fibers, but associated with them is a covering of less dense, reticular-like connective tissue whose strands are so oriented as to follow the lines of stress. Ventrally in the ligament, this secondary tissue is usually made up of two layers of cells, while dorsally, there are frequently six. The clavicular attachment of the primary part is diagonally disposed, i.e., the lateral border reaches the dorsal edge of the clavicle, whereas the medial border is attached to the ventral surface. The less dense secondary connective tissue, besides immediately covering the fibrous portion, extends medially beyond it for a distance of about 4 mm., to attach to the dorsal edge of the posterior surface of the clavicle. The entire ligament thus has a V-shaped clavicular attachment. There is an intermingling of the fibers of the coracoclavicular and acromioclavicular ligaments on the ventral surface of the clavicle.

Sternoclavicular ligament. The medial end of the clavicle is held in place by the sternoclavicular ligament. This broad, flat band extends from the ventral surface and inner tip of the clavicle to the dorsal surface of the manubrium sterni, although some fibers may pass ventrally. Within the ligament, and between the end of the clavicle and the sternum, is the flat, somewhat oval-shaped cartilaginous, sometimes partly ossified, omosternum, which Dawson ('25), who prefers Gegenbauer's term of praeclavium for this structure, considered the homologue of the sternal epiphysis of the clavicle of man. The distal end of the omosternum is expanded slightly to articulate with the clavicle. White fibrous tissue, loosely, but firmly, attaches the ventral surface of the omosternum to the dorsal surface of the manubrium. Some of these fibers are also continuous with the fibers of the ligament on the other side of the animal, forming what might be considered an interclavicular ligament. Still another ligament, probably a part of the sternoclavicular with which it more or less blends, is present. It extends from the dorsal surface of the costal cartilage to the ventral surface and tip of the medial end of the clavicle and ventral surface of the manubrium. It is considered the rhomboid ligament, and is regarded as the homologue of the rhomboid ligament of man. The sternal anchorage of the clavicle is strong, but flexible.

Although structurally the shoulder mechanism of the rat resembles that of man, functionally it is considerably more versatile because it is adapted both to tractional movements which require an adequate clavicular brace, and to quadrupedal locomotion which is considerably facilitated by a relatively narrow shoulder width. That the mechanism can function in tractional movements is indicated by the presence of a relatively strong coracoclavicular ligament. The structure and attachments of this ligament suggests that it functions somewhat as does its homologue in man stabilizing the scapula to the clavicle (cf. Liberson, '39), and assisted to some extent by the acromioclavicular ligament, forms the means whereby the forces of traction can be transmitted through the clavicle to the sternum. The manner by which the shoulder can be adapted to the needs of quadrupedal locomotion in conjunction with these tractional movements, especially as they are apt to occur in the confined passages used by rats, apparently rests in the presence of the omosternum. The presence of this structure makes possible an ample clavicular brace, and at the same time, permits an unusual flexibility in the sternoclavicular articulation which would not be possible otherwise. This flexibility is indicated by the sketches in figure 6 which illustrate the position of the omosternum during several possible movements and positions of the limb. Special attention is directed to the arrangement which permits the decrease in the width of the shoulder, and which would be of obvious importance to the animal when moving through narrow passages. Supplementary x-ray observations and photographs were made on the living animal in order to study the shoulder mechanism in a comparable situation. The animal was confined lightly between the jaws of a wood-worker's clamp. By comparing measurements and photographs made under these conditions with similar observations made on the same rat when it was quiescent and not held by the clamp, it was found that the shoulder width could be decreased 40%, i.e., from 47 mm. to 28 mm., without abnormal displacement of parts due to the methods of handling. The shoulders were moved forward into the neck region. This shift was readily accomplished by moving the scapulae anteriorly from their lateral position on the thorax into a space made available in the neck region by a series of changes in the relative positions of associated structures. The omosterna became located anteriorly to the manubrium, and their long axes, normally anterio-posterior and parallel to one another, diverged anteriorly to come into direct line with their respective clavicles. There was thus an apparent increase of 3 mm. length of each clavicle. The increase was just enough to get the scapular blades into the neck region without interfering with the supporting function of the clavicle. The neck was increased to twice its length to accommodate the blades by the stretching of the intervertebral areas.

In the remaining animals studied, the clavicle is reduced and articulates with neither the acromion process nor the manubrium. Accordingly, the primary clavicular ligaments are approaching the status of vestiges, if they have not already arrived.

THE RABBIT (fig. 3)

Acromioclavicular ligament. This ligament is represented by a flattened band about 35 mm. long and 2 mm. wide which attaches to the anterior surface of the lateral end of the clavicle in a horizontal plane, and extends laterally with but slight angulation, to attach to the acromion process of the scapula in a vertical plane. Because the planes of attachment are at right angles to each other, there is a twisting of the ligament. As a result of the reduction in the size of the clavicle, the acromioclavicular ligament is of relatively greater length than its homologue in the rat.

Coracoclavicular ligament. The considerably elongated coracoclavicular ligament is approximately 25 mm. long. It attaches to the posterior surface of the lateral end of the clavicle as a very thin, flat band, and extends directly posterior to the coracoid process.

Sternoclavicular ligament. This ligament has a uniform diameter of about 2 mm., and is about 23 mm. long. It extends from the posterior surface of the medial end of the clavicle to the very tip of the dorsal surface of the manubrium, with some of its fibers passing directly over to the ligament on the other side of the animal to form the interclavicular ligament. There is no twisting. The rhomboid ligament is not represented.

The ligaments of the rabbit, even though tractional movements persist to a degree and the clavicles are still large enough to be attributed some functional significance, have undoubtedly lost much of their importance. The relatively strong acromioclavicular and sternoclavicular ligaments, however, suggest that they may still function at least as retaining ligaments to the clavicle.

THE CAT (fig. 4)

The clavicle of the cat is considerably more reduced than that of the rabbit, and apparently it is a far more variable structure. In the fully grown animal it measures from 15–25 mm. long, and not infrequently there is as much as 5 mm. difference between the opposite sides of the same individual. With this apparent reduction, the ligaments, too, have lost their importance, and the clavicle is largely supported by associated structures. It is securely imbedded in the underside of the cephalobrachial muscle, marking the junction of the clavotrapezius, cleidomastoid, and clavobrachial muscles, and is attached to the edge of the broad, white, membrane-like costocorocoid or clavopectoral fascia. The medial portion of this membrane reaches the sternum, while the lateral part spreads to the various parts of the scapula, and then continues posteriorly to blend with the general fascia of the region. The three clavicular ligaments, much elongated, are nevertheless represented.

Acromioclavicular ligament. The acromioclavicular ligament is more variable in the cat than in the rabbit, not only varying in different individuals of comparable size, but also, sometimes markedly, between the two sides of the same individual. It is not always sharply delineated; its fibers may merge with those of the surrounding fascia. It is the longest of the three ligaments, its length ranging from 30 to 50 mm., and its width, from hair-like dimensions to 1 mm. It attaches to the acromion process, just below the apex, in a vertical plane, and its fibers intermingle with those of the coracoclavicular ligament to form a common ligament about 10 mm. long, which twists and inserts horizontally on the lateral end of the clavicle. As the acromioclavicular ligament unites with the coracoclavicular, it sends a few fibers back along the latter to the coracoid process.

Coracoclavicular ligament. Perhaps because it receives fibers from the acromioclavicular ligament, this ligament is usually the strongest of the three, although it, too, varies considerably. Compared with the others, it is short (25–30 mm. long) and broad (0.5–1.0 mm. wide). It originates from the tip of the coracoid process and attaches to the clavicle in common with the coracoclavicular ligament as described above. This attachment, which is horizontal while the coracoidal is vertical, has resulted in a twisting of this ligament also, but in a direction opposite to that of the acromioclavicular ligament.

The coracoclavicular ligament gives off two bands of fibers posteriorly to the medial surface of the capsular ligament covering the gleno-humeral articulation.

Sternoclavicular ligament. Not very strong, and often difficult to find, this ligament varies in length, measuring from 30–35 mm. long, and it varies in width from hair-thickness to 1 mm. It arises from the dorso-lateral border of the manubrium, just in front of the attachment of the first costal cartilage, and extends anteriorly and laterally to the anterior border of the medial end of the clavicle. Its manubrial attachment is horizontal, and its clavicular, vertical, and the resulting twist is in the same direction as that of the acromioclavicular ligament. Some of the fibers pass to the other side, suggesting an interclavicular ligament.

Straus-Dürckheim (1845) has been the only investigator, insofar as has been ascertained, to describe the shoulder ligaments of the cat, and he compared them with those of the human. His observations with respect to the primary clavicular ligaments, however, were faulty. He stated that the coracoclavicular and the sternoclavicular ligaments of man had no counterpart in the cat, but both have been unmistakably demonstrated although sometimes represented only by slender, somewhat poorly developed strands which could have been overlooked easily because they are thread-like and very delicate. Furthermore, he found no evidence of the elusive, but nevertheless existing, acromioclavicular ligament, and was led to conclude that it is reduced to the clavicular raphe of the cephalobrachial muscle which does not reach the scapula.

THE DOG (fig. 5)

In the dog where tractional movement of the forelimb is greatly reduced, all the clavicular parts, including the ligaments are vestigial; the shoulder mechanism closely approaches that of the ungulates. The coracoid process, quite distinct in the previous forms, is represented by a low, relatively indistinct ridge on the medial surface of the supragleniodal tubercle, and the clavicle is only a small, flattened, rectangular bone. With the reduction of the coracoid process, the coracoclavicular ligament has disappeared, and of the three primary ligaments only the acromioclavicular and sternoclavicular are present. Both are very much elongated, and because the clavicle is so small, they are virtually continuous with each other, forming the acromiosternal ligament which extends from the acromion process of the scapula to the dorsal surface of the manubrium. Even this ligament is poorly developed, and apparently is on the way towards complete disappearance along with the clavicle. A few fibers at the medial end of the sternoclavicular portion pass over the manubrium to the ligament on the other side to suggest an interclavicular ligament. There is no apparent twisting.

With the concomitant reduction of the clavicle and clavicular ligaments leading to the formation of the condition existing in the dog as described above, it is quite evident that neither the clavicle nor associated ligaments are destined to take part in the formation of clavicular raphe which crosses the belly of the brachiocephalic muscle. This inscription is undoubtedly the persisting fibrous intersection between the tendons originally attached to the clavicle before reduction occurred. Occasionally, it has been erroneously referred to as the vestige of the clavicle, especially when the clavicle has completely retrogressed as in the horse and pig. (cf. Sisson, '14). Straus-Dürckheim also had a similar misconception of the clavicular raphe in the cat (vide supra).

SUMMARY

1. The three primary clavicular ligaments, i.e. coracoclavicular, acromioclavicular, and sternoclavicular, were carefully examined in the rat, rabbit, cat and dog, and the extent of their development studied in relation to the movements allowed by the shoulder girdle.

2. In the rat, where the traction of the forelimbs calls for forcible movements against the thorax and, in consequence, a well developed clavicular brace, the ligaments, particularly the coracoclavicular, are exceptionally well developed and resemble closely those of the human.

3. X-ray studies on the rat revealed that the omosternum is an adaptation which increases the versatility of the shoulder by permitting a reduction in shoulder width. This adaptation allows the scapula to move from the thorax into the neck region by adding the required length to the clavicle.

4. In the cat and rabbit, with the reduction of the clavicle, the three ligaments are relatively longer, and also more slender, and probably, therefore, only slightly or not at all involved in the movements of the shoulder girdle.

5. The most pronounced degeneration of the ligaments was found in the dog where the dominant function of the shoulder girdle is concerned with the progressional movement of quadrupedal locomotion. The entire coracoclavicular ligament is lost along with the default of the coracoid process, and the only ligament present is the elongated acromiosternal (acromioclavicular plus sternoclavicular) in which the very much reduced clavicle is suspended.

6. The clavicular raphe is not the vestige of the clavicle and its associated ligaments, but the fibrous intersection between the tendons originally attached to the clavicle before reduction.

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FORMATION AND GROWTH OF ADRENOCORTICAL-LIKE TISSUE IN THE OVARIES OF THE ADRENALECTOMIZED GROUND SQUIRREL[1]

RICHARD A. GROAT

Institute of Neurology, Northwestern University Medical School, Chicago, Illinois

TWO PLATES (TEN FIGURES)

The adrenalectomized ground squirrel presents an interesting survival phenomenon. A lessened food intake and an inability to survive a fast are good criteria of two different levels of adrenal insufficiency in this animal. Adrenalectomy is fatal in most instances, but if the operated ground squirrel is allowed to drink 1% sodium chloride solution its food intake is maintained and it survives. At a variable time after adrenalectomy (minimum, 15 days for the female) 1% sodium chloride solution may be replaced by water and the animal will continue to eat. Later, some 3 or 4 months after operation, it will be able to survive a fast. At this time the animal is apparently normal. A gradual adjustment has been made in response to the removal of the adrenals. It has proved to be the formation of adrenocortical-like tissue in the animal. The ovaries invariably are a site of growth of this tissue.

Endocrinal aspects of this subject were discussed previously (Groat, '43). The present report is concerned with the histological interpretation of the material which consists of serial sections of both ovaries of fifty-three young and mature ground squirrels. The fixative most commonly used was an aqueous solution of 5% mercuric chloride and 2.5% potassium dichromate to which was added 1% of formalin just before use. The sections were stained with an unpublished tetrachrome stain. Seven animals, five adrenalectomized and two intact, were injected intra vitam with a solution of trypan blue, which appears in macrophages as coarse granules, in fibroblasts and certain other cells as very fine granules. It was expected that this latter material would supplement the study on the origin of the adrenocortical-like cells.

Certain of the stromal cells in the ovaries of the adrenalectomized ground squirrel undergo metaplasia into adrenocortical-like cells. The ground squirrel goes through a brief annual sexual season in the spring,

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after which the genitalia regress (Drips, '19; Johnson, Foster and Coco, '33; Foster, '34). Hence, the ratio of ovarian stroma to ovarian parenchyma is higher than in animals which have long sexual seasons. The stroma is relatively most abundant in anestrum. It consists chiefly of stromal cells and fine collagenous fibers. There are two distinct end forms of cells with intermediate forms in evidence. The cells which have scanty cytoplasm principally at the tips of the slender, fusiform, usually chromatic nuclei of varying length may be called fibroblast-like cells. They are the form most associated with the collagen fibers. The second end form comprises cells which have indistinct, stringy cytoplasm and large, ellipsoidal, semi-chromatic nuclei. The fibroblast-like cells and the undifferentiated cells probably represent two interconvertible forms of the same cell. Designation of the second form of cell as undifferentiated is arbitrary since the fibroblast-like cells themselves are not thoroughly differentiated.

Traversing the medulla of the ovary are bundles of collagen fibers and fibroblast-like cells in the arrangement of regular connective tissue. Thin sheaths having a similar but more delicate structure often surround corpora lutea and vesicular follicles. Undifferentiated cells are absent or sparse in these bundles and sheaths. Elsewhere in the medulla the collagen fibers form a feltwork of varying density. Fibroblast-like cells and undifferentiated cells are scattered through the meshes. The cortex contains little collagen: undifferentiated cells predominate. Figure 1 shows an area bordering between cortex and medulla.

Aggregates of mesenchymal-like cells associated with the epoophoron tubules in the mesovarium are also sources of adrenocortical-like cells. The mesenchymal-like cell clumps are separated from the epithelium of the tubule by a condensed layer of collagen fibers and fibroblasts (fig. 2).

The adrenocortical-like cells found in an ovary after adrenalectomy typically are large with dense cytoplasm and a large spherical semichromatic nucleus which has one or two large eccentrically located nucleoli. In the medulla and the cortex of the ovary they seem to have come from undifferentiated cells and from fibroblast-like cells. In the mesovarium they appear to have been derived from the mesenchymal-like cells associated with the epoophoron and from fibroblasts at the periphery of aggregations already formed. Occasionally foci here seem to have originated from fibroblasts.

By as early as 3 days after adrenalectomy there may be clear evidence of formation of adrenocortical-like cells in the medulla of the ovary (fig. 3) and in the mesovarium (fig. 4). Occasionally adrenocortical-like cells can not be found in the medulla up to 10 days after adrenalectomy, but they can be detected always in the mesovarium. Metaplasia progresses with time and mitosis also occurs. In many areas of recent formation it is impossible to see boundaries between cells. After 3 or 4 weeks the process has extended into the cortex of the ovary (fig. 6). In one instance cells were found in the tunica albuginea (fig. 7) and at the surface of the ovary. Clumps of adrenocortical-like cells coalesce to form larger aggregates. In an animal 118 days after adrenalectomy the medulla of the ovary was solidly filled with adrenocortical-like tissue (fig. 8), there were clumps and extensions in the cortex (fig. 9) and one large body swelled the mesovarium and extended into the ovary. Both ovaries of an animal always presented similar pictures.

The studies with trypan blue added little to the observations on the origin of the adrenocortical-like cells. The dye was seen as fine granules in some of the adrenocortical-like cells in animals sacrificed 7 days after the first injection. From the distribution of adrenocortical-like cells containing trypan blue it appeared that these cells did not themselves take up the material, but this observation must remain questionable. The dye occurred in the cells of the germinal epithelium, cells of the tunica albuginea and fibroblast-like cells, and less frequently in undifferentiated cells and theca interna cells of immature follicles.

Adrenocortical-like cells may form elsewhere as is indicated by the results of removal of the ovaries before and at various times after adrenalectomy. However, the metaplasia occurs most readily in the ovaries. On the basis of survival and resistance to fasting, metaplasia seems to occur also in the adrenalectomized male ground squirrel, but whether there is any constant locus as in the female has not been determined.

A small cortical body was found near a kidney long after adrenalectomy in one female (fig. 10). The cells seem to have arisen by metaplasia of fibroblasts. Cortical rests have not been found in the ground squirrel.

The physiological evidence for the identity of the adrenocortical-like cells is threefold. Firstly, the tissue was found in the ovaries of all adrenalectomized ground squirrels but was not found in the ovaries of any intact animals. Secondly, removal of the hypophysis prevented the appearance of adrenocortical-like cells in the ovaries after adrenalectomy. Thirdly, the state of adrenocortical insufficiency ameliorated as the amount of the adrenocortical-like tissue in the ovaries increased.

The physiological metaplasia I have described is comprehended with less difficulty if the great readiness of the cells of the coelomic wall derivatives to undergo change (Gruenwald, '42) and the probable stimulus provided by adrenotropic factor of the hypophysis are considered. Whether or not the adrenocortical-like cells are to be called epithelial is arbitrary. On broad considerations it would seem that these cells and the cells of the adrenal cortex should be termed epithelial. The adrenocortical-like cells are derived from cells of mesenchymal origin. Similarly, an undetermined number, probably most, of the adrenocortical cells of the post-natal ground squirrel adrenal are derived from fibroblast-like cells of an inner corticogenic layer of the capsule. This observation of the present author follows those of Zwemer, Wotton and Norkus ('38) and Salmon and Zwemer ('41) on other animals.

SUMMARY

Cells which are morphologically and functionally like those of the adrenal cortex develop in the ovaries of the young and the mature adrenalectomized ground squirrel. These adrenocortical-like cells arise by metaplasia from stromal cells in the ovaries and from mesenchymal-like peri-epoophoron cells in the mesovaria.

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PLATES

PLATE 1

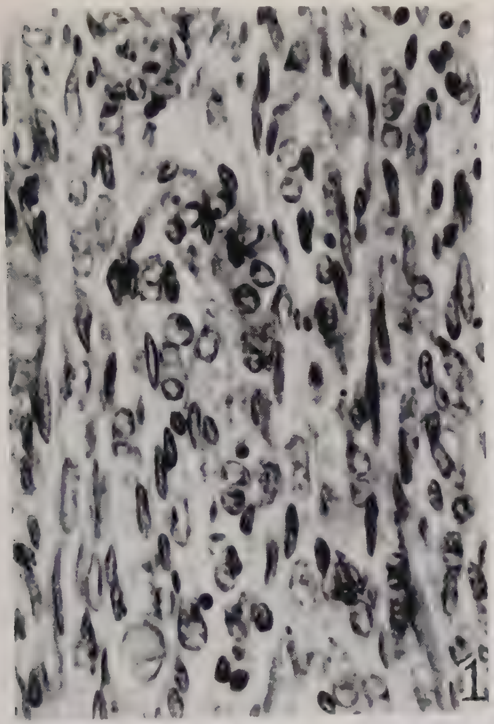
EXPLANATION OF FIGURES

1 Normal animal, killed in June. Area of ovary between medulla and cortex. Note stromal cell types. 760 ×.

2 Same ovary as in figure 1. Area in mesovarium. Upper one-third of figure, epoophoron tubule; lower two-thirds, cluster of mesenchymal-like cells; lower edge, dense connective tissue of mesovarium. 760 ×.

3 Three-day adrenalectomized animal, killed in August. Area in medulla of ovary. Note adrenocortical-like cells developing from stromal cells; mitosis in cell at upper right center; syncytial nature of some cell groups. Compare figure 1. 760 ×.

4 Same ovary as in figure 3. Area in mesovarium. Note adrenocortical-like cells developing from mesenchymal-type cells of cluster associated with epoophoron tubule. Compare figure 2. 760 ×.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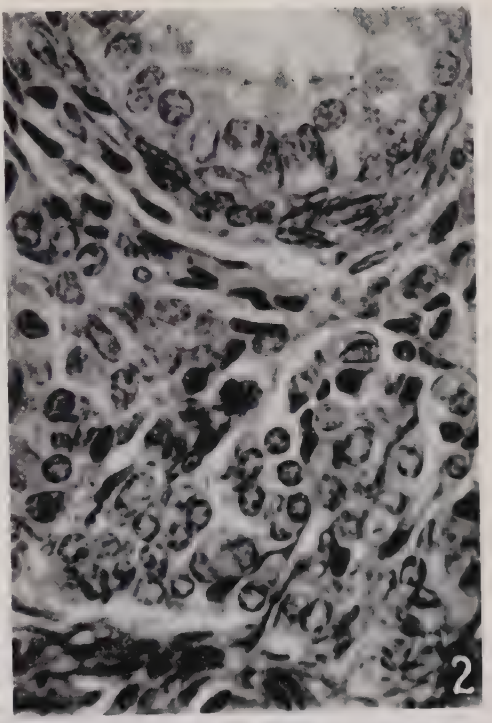
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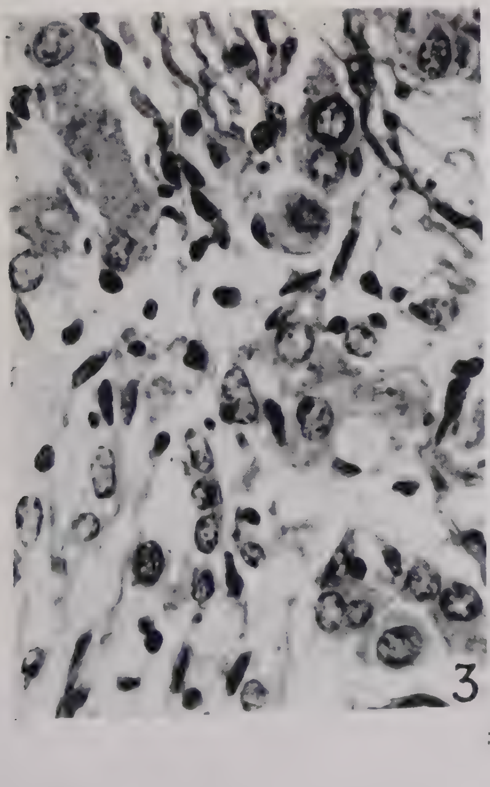
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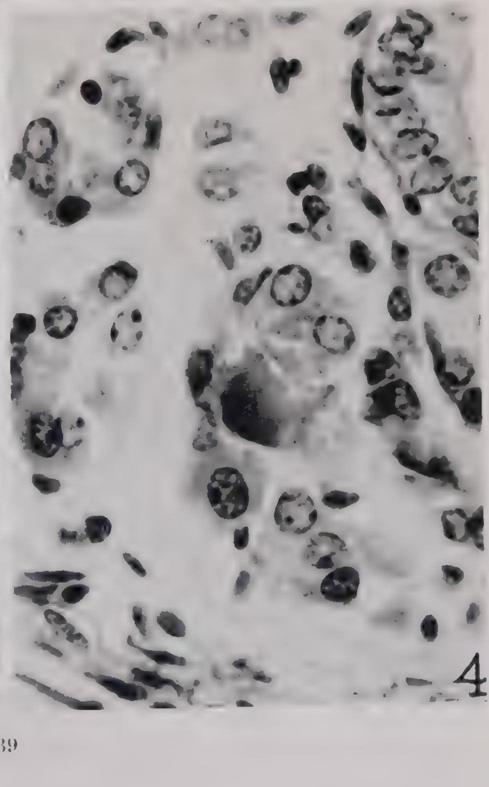
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PLATE 2

EXPLANATION OF FIGURES

5 Eleven-day adrenalectomized animal, killed in August. Area in mesovarium. Epoophoron tubule at upper right of figure. Compare figures 2 and 4. 760 ×.

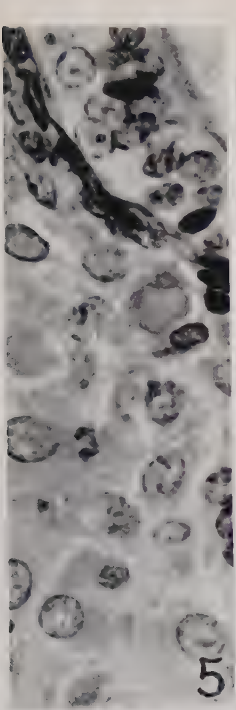
6 Twenty-six-day adrenalectomized animal, ovaries removed at biopsy in July. Area in cortex of ovary. Upper left of figure, edge of primordial follicle; upper right, surface of ovary. Note metaplasia in early stage in cortex. 760 ×.

7 Twenty-six-day adrenalectomized animal, killed in July. Area at surface of ovary. Upper left of figure, edge of primordial follicle. Note adrenocortical-like cells in tunica albuginea. 760 ×.

8 One hundred-eighteen-day adrenalectomized animal, killed in October. Cortex and medulla of ovary. Surface of ovary at upper left corner of figure. 95 ×.

9 Higher magnification of part of same section from which figure 8 was taken. Surface of ovary at upper left corner of figure; edge of primary follicle at lower left. 600 ×.

10 Three hundred-fifty-five-day adrenalectomized animal. A nodule of adrenocortical-like tissue 2 mm. in diameter was found in the dorsal body wall near the hilum of a kidney. The nodule was growing at its periphery and one end of the nodule was growing into a tendinous bundle of regular connective tissue which was giving attachment to striated muscle fibers. The figure shows part of this latter area. The dark material is coarse collagenous fibers. Note the arrangement of adrenocortical-like cells in rows, the arrangement of the fibroblasts from which they were recently derived. 650 ×.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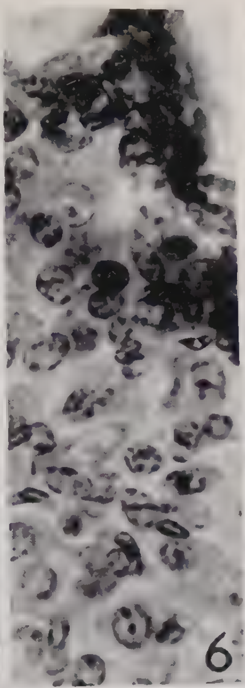
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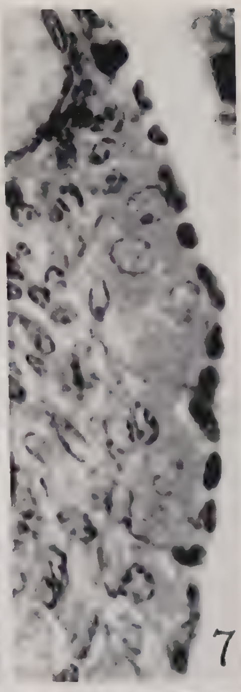
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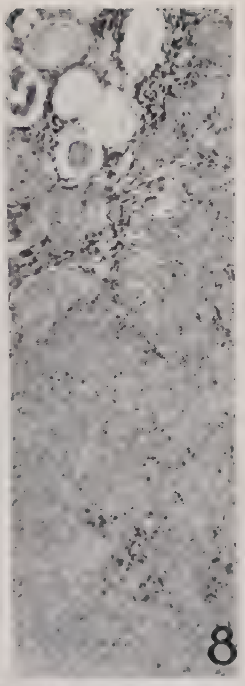
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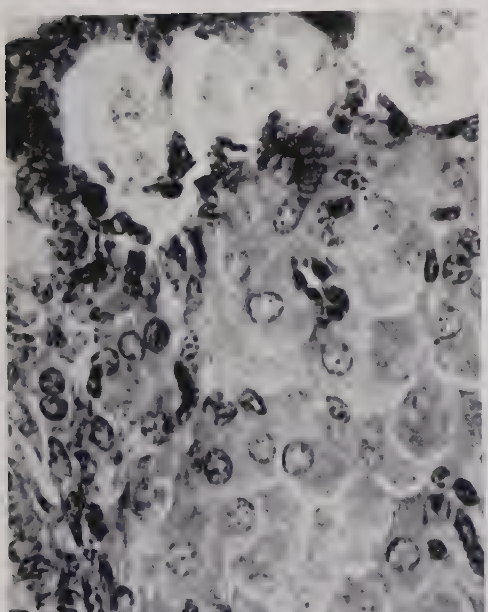
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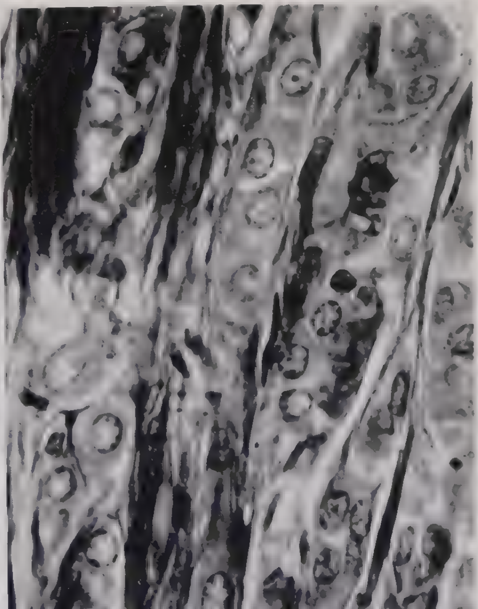
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LOCOMOTION OF BLOOD CELLS IN TISSUE CULTURES

P. P. H. DE BRUYN
Department of Anatomy, The University of Chicago, Illinois

SIX PLATES (THIRTY-EIGHT FIGURES)

Much of the hematological controversy of the past 40 years has centered around the question whether the myeloblast is morphologically sufficiently different from the lymphocyte to justify a separate classification. Besides the usual histological methods a great variety of special cytological techniques, such as supravital staining, oxidase reaction, peroxidase reaction, mitochondria, number of nucleoli, have been employed (see review by Downey, '38). However, no morphological criteria have been produced which insure a positive separation of these cell types in all instances.

In contrast to those who have placed their main reliance on certain morphological criteria for separating these cells, there are others, beginning with Dominici's classic work ('00–'02), who believe that the stem cells not only are morphologically identical but also have identical potentialities for further development — Maximow ('09), Weidenreich ('11), Dantschakoff ('16), Jordan ('19), Latta ('24), Lang ('26), Bloom ('26, '37), and to some extent Downey ('27); the latter believes that there is a morphological difference, but no potential difference.

Rich, Wintrobe and Lewis ('39) studied the myeloblast problem with a new technique. They admit that the morphological criteria of differentiation are undependable and "that no generally acceptable difference between the morphology of these cells in their dead state has yet been demonstrated to exist." They claim, however, that the living lymphoblasts and myeloblasts show a constant difference in their manner of locomotion in tissue cultures, which makes a differentiation between these two cell types possible.[1]

The locomotion of the lymphoblasts from rabbit lymph nodes is described by them as having the following characteristics: "In motion this cell preserves a rounded contour, has a few small pseudopods at the anterior margin only, and a rigid tail-like process projecting in the rear, giving the cell the general outlines of a handmirror.'' This description resembles exactly the description of the locomotion of the lymphocyte as given by W. H. Lewis ('30, '31), whose observations are confirmed by Rich, Wintrobe and Lewis. The same type of handmirror-like motion is found by them to exist in the lymphoid cells circulating in the peripheral blood in cases of human lymphoid leucemia.

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[1] Previous to them there have been efforts to differentiate blood cells by their locomotion in supravital preparations. It is my opinion that those results can be disregarded — because of the unfavorable medium in these preparations many cells don't move (see Hall's review, '38).

The myeloblasts as studied in explants from rabbit bone marrow have, according to Rich, Wintrobe and Lewis, a different type of locomotion: ''They assume an elongated cylindrical form and move in a twisting, writhing movement which makes it difficult to keep the entire cell in focus for any length of time.'' This ''wormlike'' motion was also found in myeloblasts from the circulating blood in human myeloid leucemia. The possibility is suggested by them that the type of locomotion can be used as a diagnostic criterion in cases of leucemia.

The importance of these claims is clear, not only for the study of the morphogenesis of the blood cells, but also for clinical medicine, which would thus acquire a much needed tool in the diagnosis of the leucemias.

In view of this it seemed of great interest to repeat the experiments of Rich, Wintrobe and Lewis.

MATERIALS AND METHODS

The technique used here differed only in minor details from that employed by Rich, Wintrobe and Lewis. ''Sitting drop'', instead of hanging drop, cultures of bone barrow and lymph nodes from rabbits and guinea pigs were made in heparinized homogenous plasma. In contrast to their procedure an extract of spleen was added to obtain a firm clot. Later, heparinized plasma and extract, which were frozen and dried in vacuo, were used according to the technique of Flossdorf and Mudd ('35). Before use the containers were opened aseptically and the dried material redissolved in sterile distilled water to the original volume. Hetherington and Craig ('39) found that the clotting time of frozen-dried plasma is slightly delayed. In my experience the clotting time of frozen-dried heparinised plasma is definitely shortened in comparison with the same plasma in the fresh state. This made it possible to dispense with the tissue extract, which, in addition to diluting the plasma, only serves in migration experiments to promote the clotting of the plasma.

Before photographing, the culture was transferred to a small hollow ground slide, the depression of which was filled with Tyrode solution.

This improved the optical conditions greatly because of the elimination of the refractile surface between the plasma clot and the air chamber.

Time-lapse photographs were taken on 16-mm. reversible film at a speed of 60 per minute with a 4.3-mm. fluorite oil objective, Bausch and Lomb, and an 8-x periplan ocular, Leitz. When projected at normal speed (16 per sec.) the movement was speeded up sixteen times. For the study of the migration pathways and finer details of locomotion, tracings of the cell outlines were made at intervals of 10 seconds by projecting the film on a sheet of paper (Lewis, '31). Migration pathways which were complicated by obstacles such as other cells, were not used in making tracings. Each culture which was photographed was afterwards fixed in Zenker-formol and stained in toto with hematoxylin-eosin-azure II. Twenty-eight series of about twenty-five cultures each were used for this work and 5400 feet of film were obtained for study.

OBSERVATIONS

a. Lymph node cultures

Very soon after explantation an extensive migration of lymphocytes of all sizes is seen. In studying the type of locomotion of these cells, it appeared that the "handmirror" type was present as well as the wormlike" type. By focussing it could be seen that the "handmirror" motion occurred exclusively on the surface of the coverslip, while the "wormlike" motion was limited to the cells moving within the plasma clot (figs. 1, 2, 3, and 4).

The locomotion of the lymphocytes on the coverslip surface shows the characteristics of the handmirror type as described by Lewis ('31): Three parts can be distinguished: (1) an active anterior part where the pseudopods are formed, (2) a relatively quiet body, (3) a passive posterior part or tail. Periods of migration are interrupted by periods of rest, in which the cell rounds up and frequently throws out and retracts small pseudopods without locomotion. No typical difference could be found in locomotion between the lymphocytes of different sizes, as is claimed by Rich, Wintrobe and Lewis. According to them the older forms (i.e. the smaller ones) have a tendency to "change their shape and direction of motion more frequently than do the immature forms." My material does not confirm this. All the lymphocytes moving on the coverslip, irrespective of their size, show a typical handmirror form. Their migration pathways, as revealed by cell-tracings, are identical. They move in a path which forms a smooth zig-zag line (fig. 36). Abrupt changing of direction does occur rarely during a migration period. However, after a rest-period the migration may proceed in any direction and the new migration pathway, although in itself smooth, may form a sharp angle with the previous one.

The locomotion of the lymphocytes within the plasma clot shows, as stated above, the typical characteristics of the ''wormlike'' motion, which Rich, Wintrobe and Lewis ascribed exclusively to myeloblasts.

To their description of this type of motion a few items may be added: the elongated cell body always shows constrictions which may vary in number from one to five. On the average two or three are present. They form a very characteristic feature of the cells moving inside the plasma clot. A tail-like process at the end is not as constantly visible as in the lymphocytes moving on the coverslip surface, but is still present in many cases. This can be explained by the elongation of the cell, which results in a narrowing of the cell body. The transition between the body and the tail is less sharp and the tail becomes less conspicuous. Owing to the less favorable optical conditions it is not possible to observe finer cytological detail in the cells in the clot. The three dimensional character of the wormlike locomotion renders tracings on paper of questionable value for the study of their locomotion pathways. Observations and study of the motion pictures show that lymphocytes moving in the clot do not move in a regular wavy line as on the surface, but in an irregular unpredictable manner. Complete reversal of their direction of motion in which the tail end becomes the front and the anterior pseudopodal area the tail, as Rich, Wintrobe and Lewis claim, was, however, not seen by me. More than in the lymphocytes moving on the surface the locomotion periods are interrupted by rest periods. These rest periods differ, however, from the rest periods of the surface lymphocytes in this respect that the cell does not round up, but maintains its elongated shape. Very frequently a rhythmic ''pulsation'' of the cell body occurs, giving the impression that the cell advances and retreats over a small distance which is but a fraction of the length of the cell body. It seems as if the cell is not in complete rest, but advances repeatedly against an obstacle which does not move. Besides this, regular rest periods occur, during which the cell rounds up.

Gradually progressive transformations in the lymphocytes take place in the older lymph node cultures. These transformations and the changes in locomotions, which accompany them, will be discussed in a separate paper.

b. Bone marrow cultures

The variety of cells which migrate from the explant of bone marrow is much greater. The granulocytes [2] moving on the flat surface of the coverslip display a type of motion which has a more or less close resemblance to the handmirror-motion of the lymphocytes (figs. 5–12). As in the lymphocytes, three parts can be distinguished. The separation of these three parts is, however, not as sharp as in the lymphocytes. The pseudopodia, which are frequently more numerous are not limited to the anterior part of the cell as in the lymphocytes but appear often at the side of the cell body (b in fig. 10). The tail is usually smaller and not as constantly present as in the lymphocytes and is frequently withdrawn, so that the body has a blunt end (a in fig. 10). The broad anterior margin and the less prominent tail suggest that the polarity of the granulocytes is less pronounced than in the lymphocytes. This is confirmed by studying the migration pathways. Compared with the pathway of the lymphocytes, the migration of the granulocytes is extremely irregular: sudden changes of direction and complete reversals occur frequently (g_1–g_6 in figs. 24–29, and fig. 38). The lesser degree of polarity as compared with the lymphocytes is a characteristic feature of the locomotion of the granulocytes. This is in agreement with Rich, Wintrobe and Lewis ('39) and W. H. Lewis ('30), but at variance with a later paper by Lewis ('34) in which he stresses the similarity of the locomotion of polymorphonuclear neutrophiles with lymphocytes. In the same paper a migration pathway is depicted of presumably a polymorphonuclear neutrophile, which is not different from my pictures of the path of a lymphocyte on the coverslip.

The locomotion of the granulocytes inside the plasma clot resembles in every respect a "wormlike" motion (figs. 16 and 23).

Besides the granulocytes we find in the bone marrow cultures nongranular cells of the size of a large lymphocyte. The nucleus is relatively large and one or more very large and prominent nucleoli are present (figs. 17–22). They are morphologically undistinguishable from the large lymphocytes in the lymph node cultures. I have identified them on the basis of the above described appearance, as hemocytoblasts (the myeloblasts of Rich, Wintrobe and Lewis).

The locomotion of the hemocytoblasts resembles in every respect that of the lymphocytes. In other words, on the coverslip they have the handmirror shape which has the extremely polarised character of the lymphocytes. The migration pathway is the same as that of the lymphocyte (fig. 37). In the plasma clot the hemocytoblast has a wormlike motion, which as we already indicated, has no demonstrable differences for the various cell types (fig. 23).

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[2] I could not detect any difference between the locomotion of the neutrophiles and the eosinophiles. I do not have sufficient information on the locomotion of the basophiles.

The accumulation of granules in the progressive development of the granulocytes obscures the nucleus and makes impossible a finer differentiation of later stages in the development of the more mature granulocytes in the living cultures. The very young myelocytes however, have few and small granules. These cells are clearly recognizable (figs. 13 and 14). The cytoplasm of these cells is more abundant than that of the hemocytoblasts, and is not as homogeneous as the latter but contains several small granules. The nucleus sometimes still shows the large nucleolus of the hemocytoblast (c in fig. 13). It is not difficult to see that the locomotion of these young myelocytes is of a type intermediate between the strictly polarised handmirror motion of the hemocytoblast and the irregular motion of the older granulocytes. On the coverslip a tail is practically always present and rarely completely withdrawn as in the older granulocytes. The anterior pseudopodal area is more irregular and more varying in position than in the hemocytoblasts but more confined to the anterior margin of the cell than in the granulocytes. Their migration pathways have also an intermediate character.

The cells of the red blood cell series (erythrocytes, normoblasts and erythroblasts) do not show active locomotion. However it seems that the cytoplasm of the polychromatophile erythroblast (fig. 15), which in our cultures were clearly recognizable by their typical "checkerboard" arrangement of the chromatin, is not completely inactive. The nuclei of these cells have a slightly rotating movement back and forth, the mechanism of which is not clear. The more hemoglobin-containing cells as the normoblast did not show this phenomenon, but appeared completely quiet.

I have had the opportunity several times to observe in the time-lapse motion pictures how a cell moving on the coverslip in a handmirror fashion leaves the coverslip and assumes the elongated wormlike shape. In doing so the cell moved out of the plane of focussing, indicating that it left the coverslip. Plates 4 and 5 demonstrate this for a granulocyte and a hemocytoblast.

Occasionally the conditions inside the clot are such that a cell in handmirror shape is visible. This may happen when large liquid spaces are present; these are formed by fibrinolysis, or from other causes. In such places the cells round up by the lack of a solid support. They are not in active motion. Occasionally they might push out a small free pseudopod, which later is pulled in again, without being accompanied by active locomotion. Sometimes there is a slight streaming of the serum in such liquid spaces and with such a pseudopod extended the cell can float around over a short distance. This resembles a handmirror motion. The same might occur in a rest period in a solid part of the clot, without the motion, however. These conditions, which have nothing to do with the handmirror shape in active motion can be easily recognized by their irregular and unpolarised nature. Instead of having an anterior pseudopodal area and a tail at the end these passively moving cells will have the tail at any side. An anterior pseudopodal area is never present.

DISCUSSION

We have stated above that in accordance with Lewis ('34) a leucocyte moving on a flat surface can be divided into three portions: (1) an anterior portion, which is the most active in locomotion; this portion gives rise to the pseudopodia, (2) a relatively quiet body, which contains the nucleus, (3) a posterior part, the tail, which appears to be completely passive. The tail does not have a constant appearance and may vary not only in the different cell-types, but also in the same individual.

This shape is apparently characteristic for amoeboid motion in general. Jennings ('04) describes a moving amoeba as having a broad thin anterior part and a narrower and thicker posterior part on which can be present an appendage (tail).

The presence of an active anterior area and a passive posterior area in a moving leucocyte may be expressed as polarity. It is this polarisation, or rather the degree of polarisation, which is characteristic for the different types of leucocytes in motion. The lymphocytes and hemocytoblasts with their pseudopodal area confined to the anterior part of the moving cell and the very pronounced tail, are definitely the most polarised. The direction of locomotion shows no abrupt changes and the migration pathway is a wavy line with smooth curves.

The granular leucocytes are also polarised, but to a lesser degree. The pseudopodal area varies in position and the pseudopodia are more numerous. The tail is usually smaller and often withdrawn. The migration pathway is irregular with many abrupt changes in direction and even complete reversals occur. In connection with this it is interesting to point at an observation of Schaeffer ('20). He observed that the smooth wave-like path of Amoeba proteus could become suddenly irregular. Associated with this change was the formation of more numerous pseudopods.

The myelocytes have a degree of polarisation, which is intermediate between the two above-mentioned cll groups.

The above description does not hold, however, if the solid support for the moving cell is not a flat surface. The solid support inside the plasma clot is the fibrin network. It is clear that the nature of this lattice forces the cell to give up its flattened appearance. The cell stretches out along the fibrin fibers and becomes elongated. The difference in size between the tail and body diminishes with the result that the tail becomes less prominent. The pseudopodal area is narrowed. In this shape the cell moves along and turns around the fibrin threads through the spaces available in the three dimensional network. This explains why cells in wormlike motion are difficult to keep in focus as observed by Rich, Wintrobe and Lewis. This wormlike motion was seen by Maximow ('22) in lymph node cultures.

It follows from this that neither the handmirror nor the wormlike shape is typical of certain cell types.

The adhesion to the coverglass is a factor of considerable variation. Sometimes a culture series showed no cells adhering to the coverglass at all and consequently no handmirrors, but only worm-shape cells. Fenn ('23) has investigated the adhesiveness of leucocytes to glass and found that among other factors the hydrogen concentration is of great importance: leucocytes appeared to be most adhesive to glass at a slightly alkaline pH. We did not control the pH of our medium and the possibility exists that slight variations in the pH account for this irregularity in our cultures.

SUMMARY

The locomotion of the blood cells has been studied in tissue cultures from rabbit lymph node and bone marrow by means of time-lapse motion pictures.

All blood cells moving on a flat surface present the general shape of a "handmirror", that is, they have a relatively quiet cell body, an active anterior pseudopodal and a passive posterior part. The handmirror shape is most typical in the moving lymphocyte and hemocytoblast. Their type of locomotion is identical.

The lymphocyte and hemocytoblast in locomotion are polarised cells. A gradual loss of polarisation takes place in the development from hemocytoblast into mature granulocyte. By this the "handmirror"

BOSTON MEDICAL
OCT 9 - 1944

type of motion becomes less pronounced in the mature leucocytes, but is still recognizable.

When moving inside the plasma clot, all blood cells have a ''wormlike'' motion. This type of motion is the result of the ''brush-heap'' structure of the fibrin in the plasma clot of mammals.

The manner of locomotion cannot serve as a means of differentiating the myeloblast from the lymphoblast.

The identity of the manner of locomotion of the stem cells from bone marrow and of the lymphocytes from lymph node is another instance of the lack of criteria in separating the two cell lineages.

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EXPLANATION OF PLATES

The figures of plates 1–5 are enlargements from time-lapse photographs on 16-mm. film with Bausch and Lomb objective 4.3 mm. fluorite oil and Leitz 8 × periplan ocular. Final magnification 1300 ×.

The figures of plate 6 are tracings of cell outlines as obtained by projecting the film on paper with ten frames (in reality 10 seconds) interval.

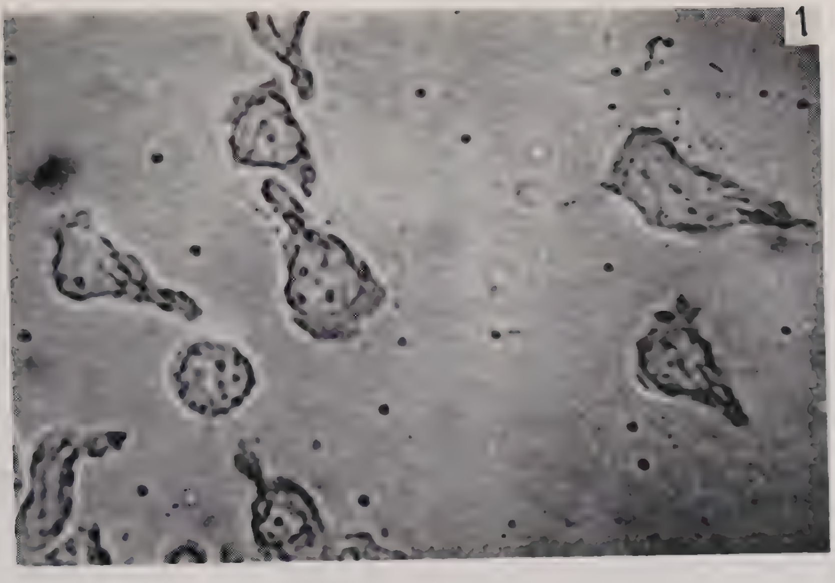
None of the cultures was older than 16 hours.

PLATE 1

EXPLANATION OF FIGURES

Cultures of rabbit lymph node.

1 Lymphocytes moving on the coverslip. "Handmirror" shape.
2 Lymphocytes moving inside plasma clot. "Wormlike" shape.



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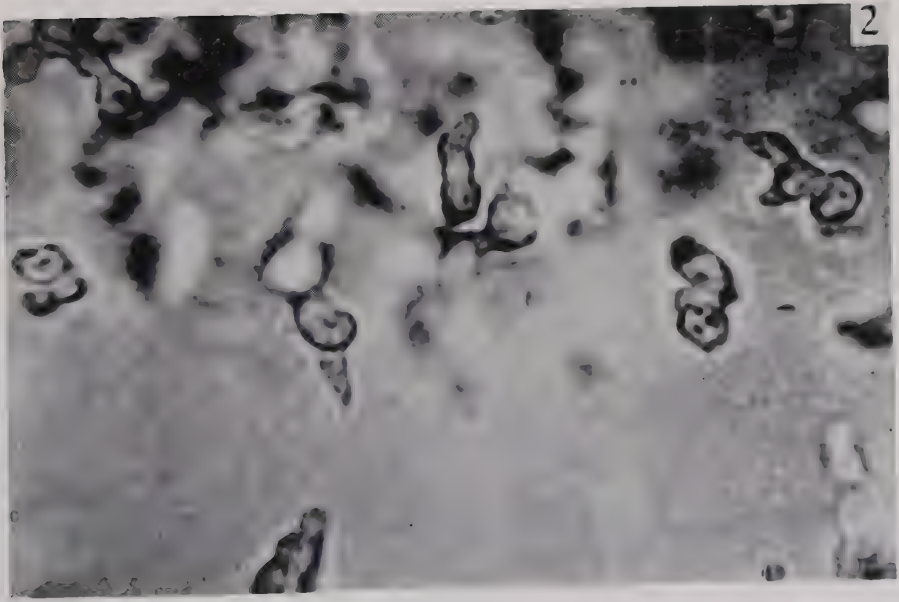

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PLATE 2

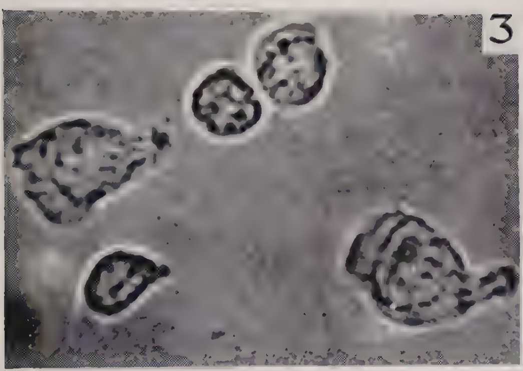
EXPLANATION OF FIGURES

Cultures of rabbit lymph node.

3 Lymphocytes moving on the coverslip. ''Handmirror'' shape.
4 Lymphocytes moving inside plasma clot. ''Wormlike'' shape.

Cultures of rabbit bone marrow.

5–12 Heterophile granulocytes moving on coverslip. Handmirror type of motion. Tail withdrawn at a in figure 9. Note lateral pseudopodia at b in figure 10.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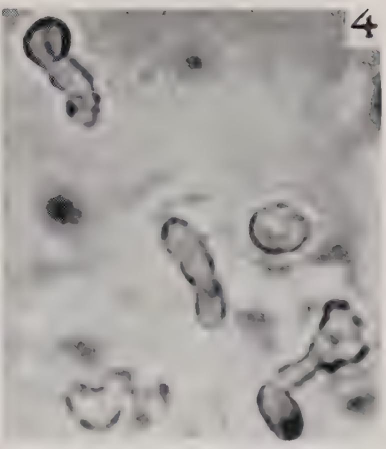
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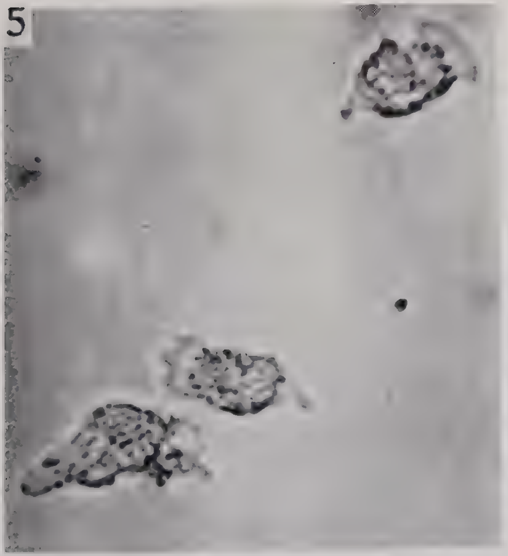
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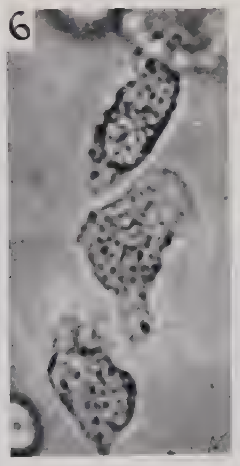
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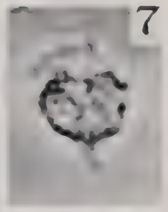
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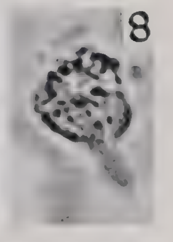
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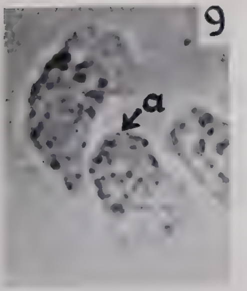
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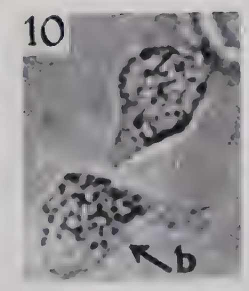
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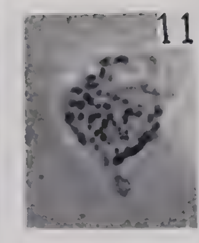
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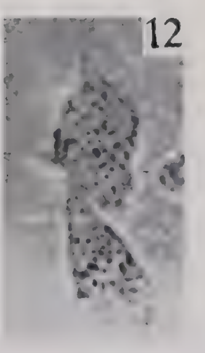
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PLATE 3

EXPLANATION OF FIGURES

Cultures of rabbit bone marrow.

13 Two myelocytes on coverslip. Cell at c is in motion and shows handmirror form. Cell at d is not moving.

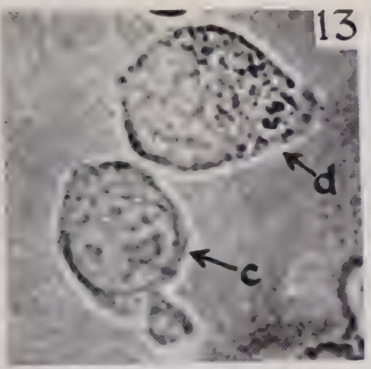
14 Two young myelocytes moving on coverslip (e and f). Handmirror type. Normoblast at g.

15 Polychromatophile erythroblasts with characteristic ''checker-board'' arrangement of chromatin.

16 Heterophile leucocytes moving inside plasma clot. Wormlike motion.

17–22 Hemocytoblasts on coverslip. Handmirror motion.

23 Hemocytoblast (h) and heterophile leucocyte (i) moving inside the plasma clot. Wormlike motion.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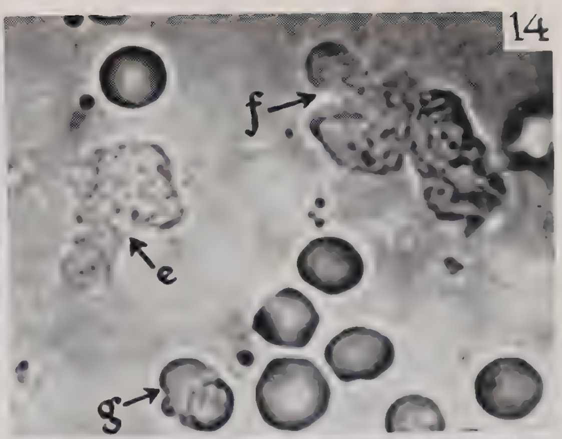
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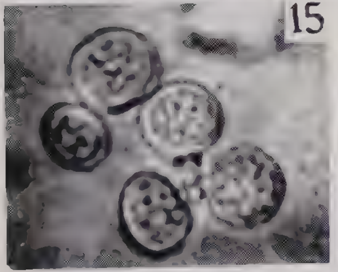
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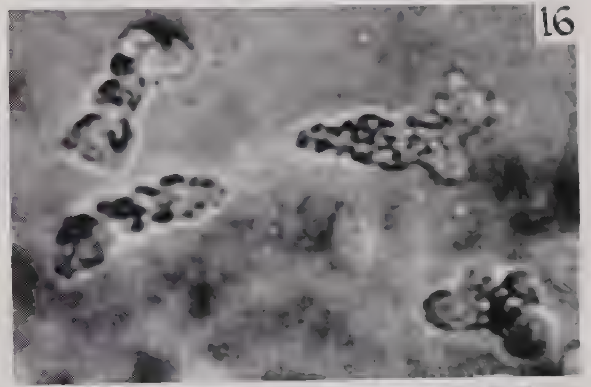
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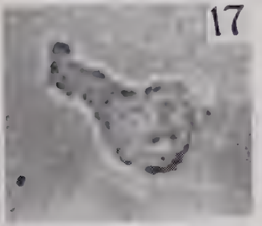
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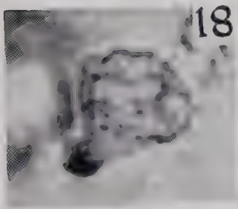
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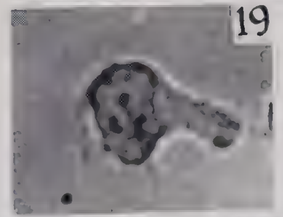
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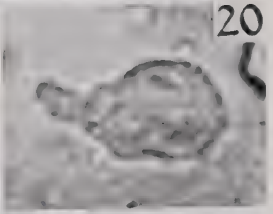
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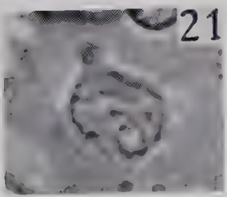
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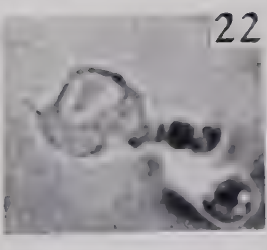
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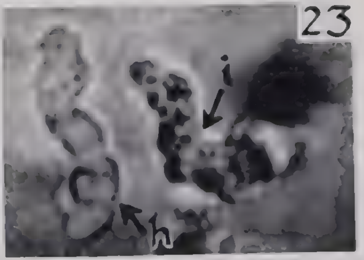
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PLATE 4

EXPLANATION OF FIGURES

Cultures of rabbit bone marrow.

The same heterophile leucocyte in handmirror motion on coverslip and in wormlike motion inside plasma clot.

24 Heterophile leucocyte (j_1) moving on coverslip. Handmirror motion.

25 The same cell (j_2) with the anterior portion detached from coverslip (out of focus).

26 The same cell (j_3) with the major part of the cell body inside the plasma clot. Wormlike shape.

27 The anterior portion of the same cell (j_4) has returned to coverslip and is again in focus. The posterior portion (out of focus) is still inside the plasma clot.

28 The same cell (j_5). The major portion of the cell body has returned to the coverslip.

29 The entire cell (j_6) is back on the coverslip and presents again the handmirror shape.

The same series of photographs shows a metamyelocyte abruptly changing its direction of locomotion (see text).

24 The cell (k_1) moves in the direction of the arrow. The pseudopodal area is in front. The tail is withdrawn and the posterior part is blunt.

25 A new pseudopodal area has formed at the lateral side of the cell (k_2).

26–29 The cell moves in the direction of the newly formed pseudopodal area and has changed abruptly the direction of locomotion (k_3–k_6).

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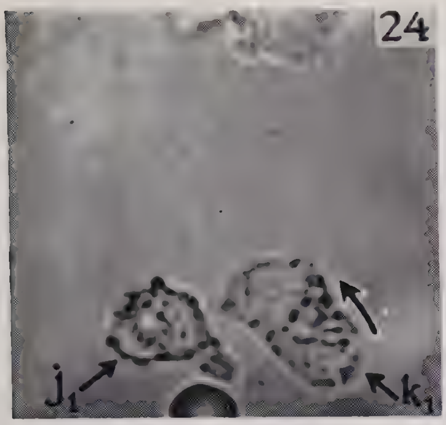

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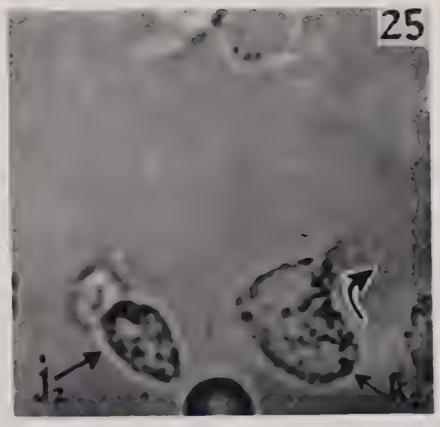

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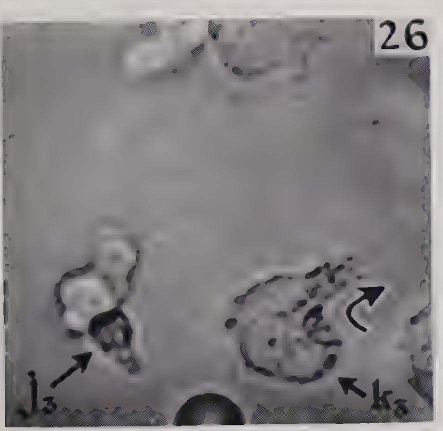

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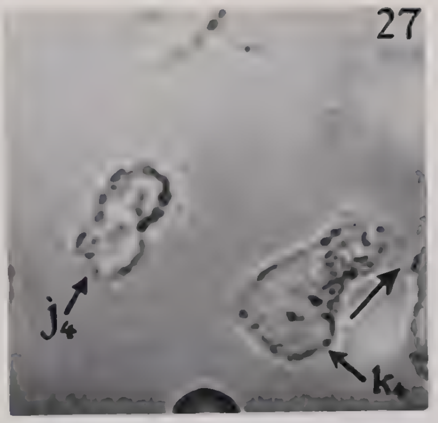

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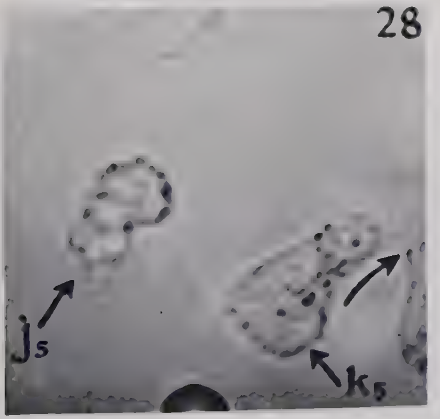

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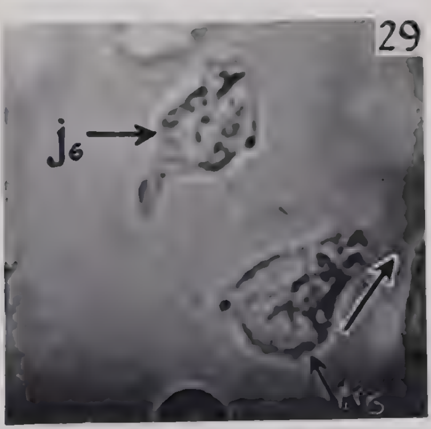


PLATE 5

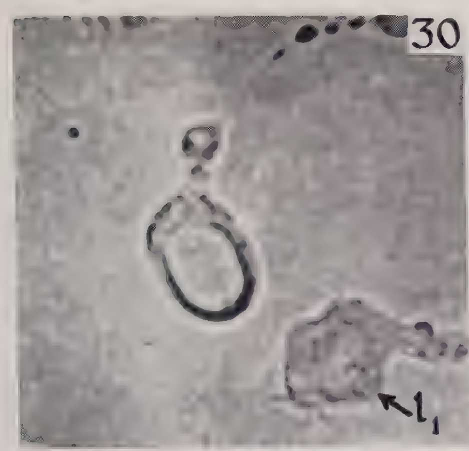
EXPLANATION OF FIGURES

Cultures of rabbit bone marrow.

Hemocytoblast leaving the coverslip and transforming from handmirror to wormlike shape.

30–31 Hemocytoblast (l_1 and l_2) moving on coverslip in handmirror shape. The cell with the large vacuole is degenerating.

32–35 The anterior part moves from the coverslip to inside the plasma clot and at l_5 the wormlike shape is evident.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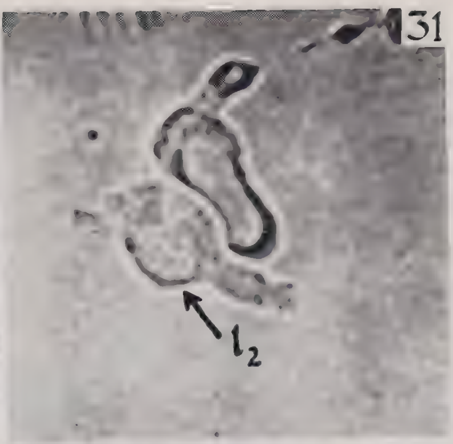
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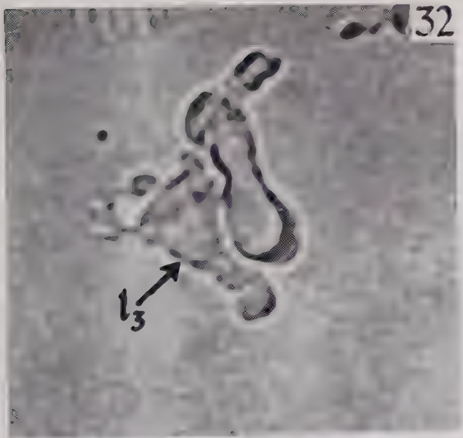
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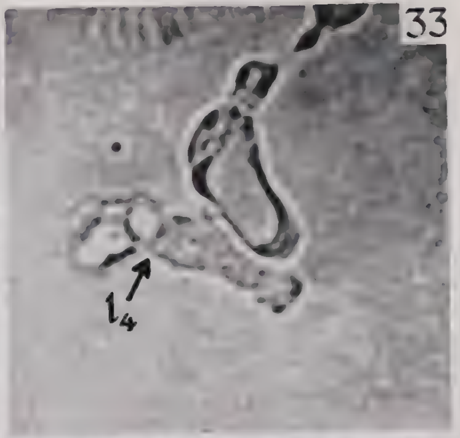
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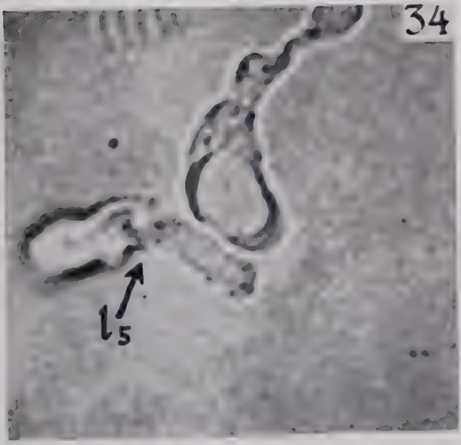
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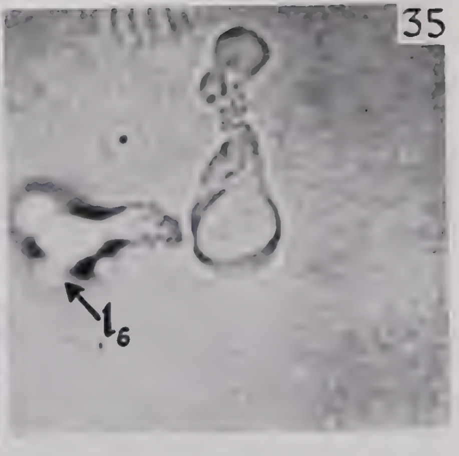
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PLATE 6

EXPLANATION OF FIGURES

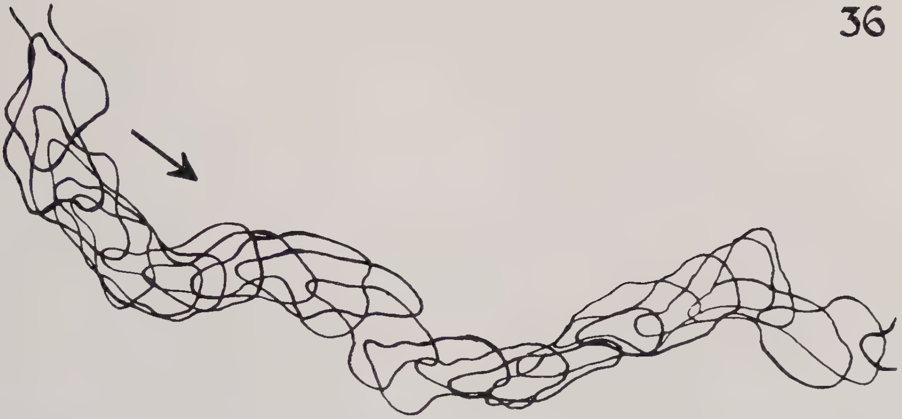
Migration-pathways of leucocytes moving on the coverslip.

36 Migration pathways of lymphocyte. Note the absence of abrupt changings of direction.

37 Migration pathway of hemocytoblast, presenting the same smooth zig-zag line as the migration pathway of a lymphocyte.

38 Migration pathway of heterophile leucocyte. Note the abrupt changings of direction.

36



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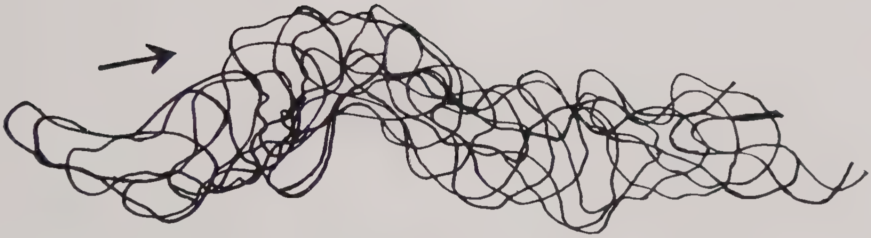

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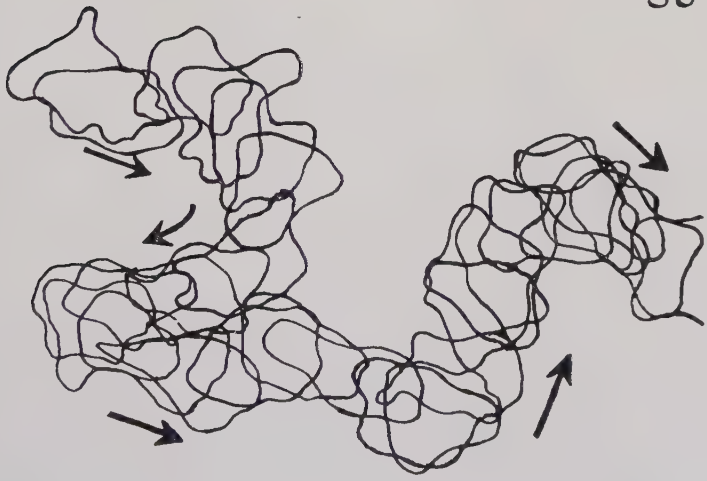

A METHOD FOR VISUALIZING THE BLOOD VESSELS OF NERVES AND OTHER TISSUES[1]

JOSEPH EPSTEIN
Neurosurgical Service and the Department of Laboratories of the Jewish Hospital of Brooklyn, New York

TWO FIGURES

In studying the fine vascular structure of an organ by means of roentgenography, the injection mass employed must fill and sharply define the vessels in a uniform manner. A mixture of red lead in glue was found to yield more satisfactory results than the commonly used preparations such as barium sulfate in gelatin (Hinman, Morrison and Lee-Brown, '23; Gross, '17) barium sulfate in agar (Hinman, Morrison and Lee-Brown, '23; Schlessinger, '38), red lead in gelatin and red lead in agar. The injected arteries could also be studied after the specimen had been cleared by means of the Spalteholz technique or by one of its variations. The mixture is inexpensive and is simple to prepare and use. The technique was first used to study the blood vessels of the sciatic nerve in dogs. It has subsequently proved useful in defining the vascular supply of other tissues.

The red lead (Pb304) and carpenters' glue used in the present technique may be purchased in a painters' supply store. The glue is prepared for use by adding 400 gm. of the chips to 1000 cc. of tap water and heating the mixture in a double boiler, stirring until all of the hard chips dissolve. It is then filtered into a flask through eight layers of gauze. The injection mass is prepared the day that it is to be used. Into a 500 cc. flask placed on a balance, 150 gm. of red lead are introduced. To this is added 150 gm. of the carpenters' glue mixture described above and 200 cc. of tap water. The mixture is stirred thoroughly before use and is kept in a hot water bath just bearable to the touch. Immediately preceding the injection, the mixture is filtered through twelve layers of gauze. If small quantities of the injection mixture are needed a commercial glue preparation such as Le Page Liquid Strength Glue may be substituted for the standard carpenters' glue.

The apparatus used for the injection was suggested by Narat ('36), (fig. 1). It consists essentially of a tank of compressed air (A), a

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[1] This study was aided by a grant from the Dazian Foundation.

reducing valve (B) and a liter flask (C) which damps the initial force of the compressed air and permits a steady flow to enter the injection flask (E) under a maintained pressure recorded by a mercury manometer (D). To operate the apparatus, the tank valve is opened and the air flow regulated by means of the reducing valve. A safety valve placed at (F) allows the operator to release the pressure in the system suddenly or slowly. The injection medium is placed in the receiving flask (E). The valve (screw clamp) located on the rubber tubing (G) leading to the flask (E) controls the flow of compressed air. By opening this slightly, the cannula may be filled with the injection medium prior to its insertion into the vessel. This valve is opened widely during the process of injection.

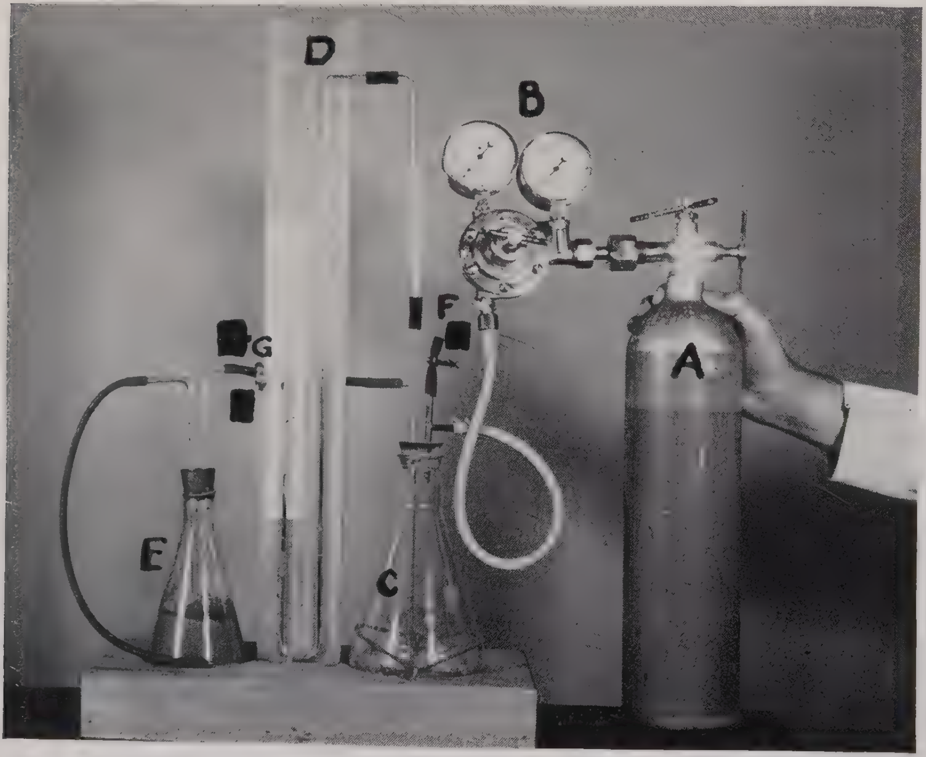

Fig. 1 Photograph of the apparatus designed for the intravascular injection of radio-opaque media. For explanation, see text.

For the study of the vascular supply of the sciatic nerve, the injection is performed through the abdominal aorta. The cannula is inserted just below the origin of the renal vessels, care being taken to avoid placing the cannula tip in either of the common iliac arteries. At first, perfusion with isotonic and hypertonic saline solutions before injection was performed. This was discontinued since it was discovered that better and more uniform results could be obtained without preliminary perfusion. Bleeding of the animal prior to injection did not prove essential for the success of the injection which may be performed as late as 48 hours following death.

The abdominal aorta and the inferior vena cava after their exposure through a mid-line incision, are ligated just below the origin of the renal vessels. A third untied ligature is placed around the aorta 1 cm. below the first. The cannula is then prepared for insertion into the aorta. The pressure is raised in the injection apparatus to 180 mm. of mercury which represents the upper limit of the dogs' blood pressure (Howell, '11). The injection flask (E) containing the red lead mixture is attached to the system leading to the cannula and the stop-cock (G) is slowly opened permitting the mixture to enter the cannula. When filled, the cannula tubing is clamped, an incision is made into the aorta immediately below the first ligature and the cannula inserted and tied in place. The vena-cava is then severed. The injection pressure is checked and readjusted to 180 mm. Hg., the valve at (G) opened widely, the clamp on the cannula tubing removed and the injection performed. During the injection period of 15 minutes all bleeding vessels are carefully clamped and the legs of the animal alternately flexed and extended. When rigor mortis is present the limb is massaged. Following the period of injection, a clamp is placed on the aorta below the tip of the cannula and the latter removed. The animal is left in the ice box or at room temperature for 2 or more hours after which period the nerves may be removed. If removed sooner, the injection mixture in the larger vessels tends to escape when the vessels are severed, thereby obscuring the field of dissection. The interval of standing permits settling of the red lead to occur while the fluid portion diffuses out of the vessel. Small arteries are completely filled and may be cut but the large vessels must be clamped prior to their severance.

Following removal of the nerve, roentgenograms are made using a 5 inch cone and fast, non-screen film. The target distance is 30 inches, milliamperage 30, kilovoltage 30–33, and 0.75 seconds. The pattern of vascularity appears well defined on the x-ray film. The nerve may then be prepared for microscopic study or may be placed in formalin preparatory to clearing of the tissue.

To facilitate the study of both the large and the small vessels of such organs as the kidneys, intestines, liver, lungs and spleen, a double injection technique was employed. The first injection, using the standard mixture and procedure described, filled the fine vessels. It was followed by the injection of a second radio-opaque mass which remained in the large vessels. This second mass was capable of setting on cooling and formed a firm cast of the vessel into which it was forced, thereby, preventing the occurrence of oozing when the vessels were cut during dissection.

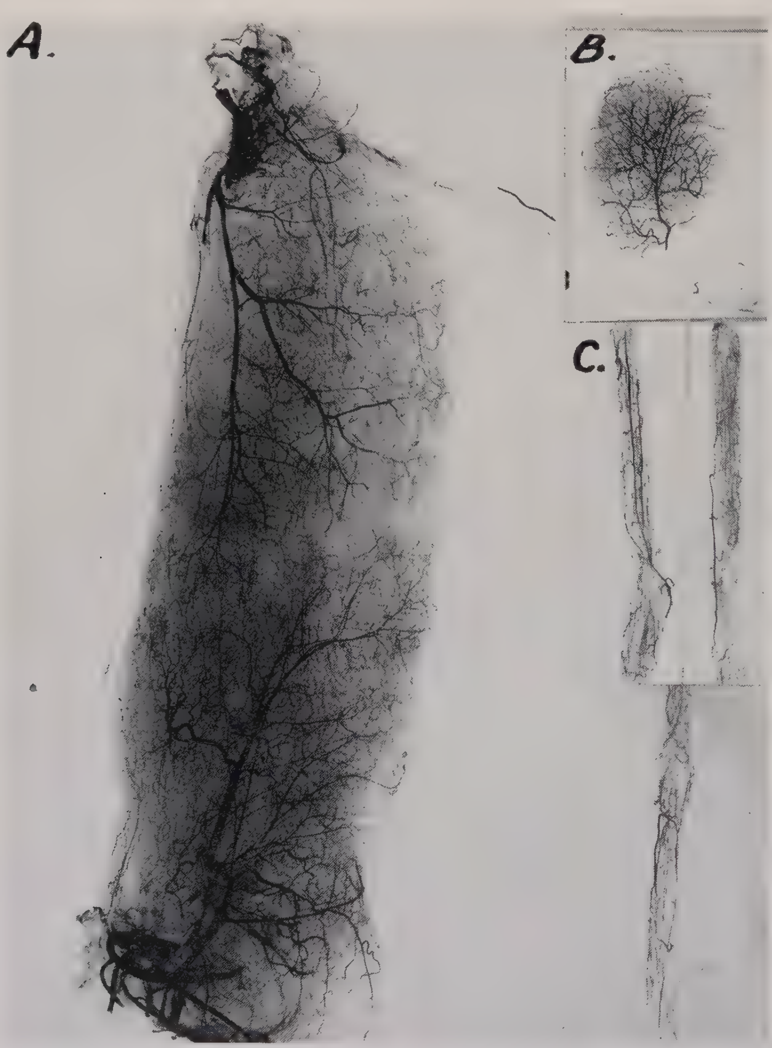

Fig. 2 Contact prints of roentgenograms of: A — biceps muscle, b — lymph node, c — sciatic nerves of a dog following the intravascular injection of a mixture of red lead and glue.

The second injection mass was prepared in one of several ways. Suspensions of red lead in agar and in gelatin proved satisfactory.

However, the best results were obtained when a heavy suspension of red lead in highly concentrated carpenters' glue was used. The glue mixture was prepared by adding 500 gm. of the dry glue chips to a liter of water, heating and stirring in a double boiler until dissolved. The injection mass was prepared by adding 300 gm. of red lead to 500 cc. of the concentrated glue mixture, warming and mixing until a homogeneous suspension of creamy consistency was achieved. Prior to injection, it was filtered through eight layers of gauze. Following injection, the vessel was tied below the cannula, the cannula removed and the animal placed in a cold water bath or in the ice box until solidification of the mass occurred.

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PARTIAL INVERSION OF THE DUODENUM

GERHARDT VON BONIN
Department of Anatomy, School of Medicine, University of Illinois, Chicago

ONE FIGURE

In a male white cadaver dissected by freshmen students the course of the duodenum was as follows (fig. 1). The pars horizontalis superior was about 5 cm. long and intraperitoneal. The pars descendens coursed for about 8–10 cm. just to the right of the midsagittal plane close to the vertebral column. The duodenum then bent sharply toward the right and dorsad to form a pars ascendens. This part was retroperitoneal, lodged between kidney and vertebral column. About 2 cm. below the level of the pylorus, the duodenum assumed a horizontal course hugging the cranial border of the pancreas, and running between aorta and superior mesenteric artery. The flexura duodeno-jejunalis was to the left of the vertebral column.

The descending part was intraperitoneal except for 1 or 2 cm. of its most caudal part. The ductus choledochus entered this descending portion at about its middle, and a little on its right side. The duct was joined in the usual manner by the pancreatic duct. No accessory pancreatic duct could be found. The pancreas extended to the right as far as the ascending part and sent a hook-like prolongation into the corner between descending and ascending part.

Thus the lower part of the duodenum was curved in a sense opposite to that normally found.

Similar cases have been described by Lochte (1898), by Anderson ('23) and by Nat and Mookerji ('30). Lochte states, however, that the aboral part of the duodenum coursed in front of the superior mesenteric vessels. Wanke ('29) gives an x-ray photo (loc. cit. p. 251) which suggests a positional anomaly of the kind described here, but the author's sketches indicate a different behavior. Since these sketches are undoubtedly based on observation before the screen as well as on the published photographs we are not justified in including Wanke's observation, although his case must remain suspicious. There is some resemblance between our case and Breton's ('34) "image d' infraversion". Breton's scheme differs, however, from our observation in the position of the duodeno-jejunal flexure. The French author puts it much higher.

The inversion described here is evidently due to an inversion during ontogenesis of the movement of the umbilical loop. Pernkopf ('26) discusses this possibility in conjunction with Lochte's (1898) case cited in the previous paragraph. He rejects that observation as an example of the mechanism just alluded to, mainly on account of the relation between superior mesenteric vessels and aboral portion of the duodenum, and continues: "Whether such a form of the duodenum in which the upper part shows a positional type opposite to that of the lower part, can be realized, must be left open." It seems as though the present case does realize this form.

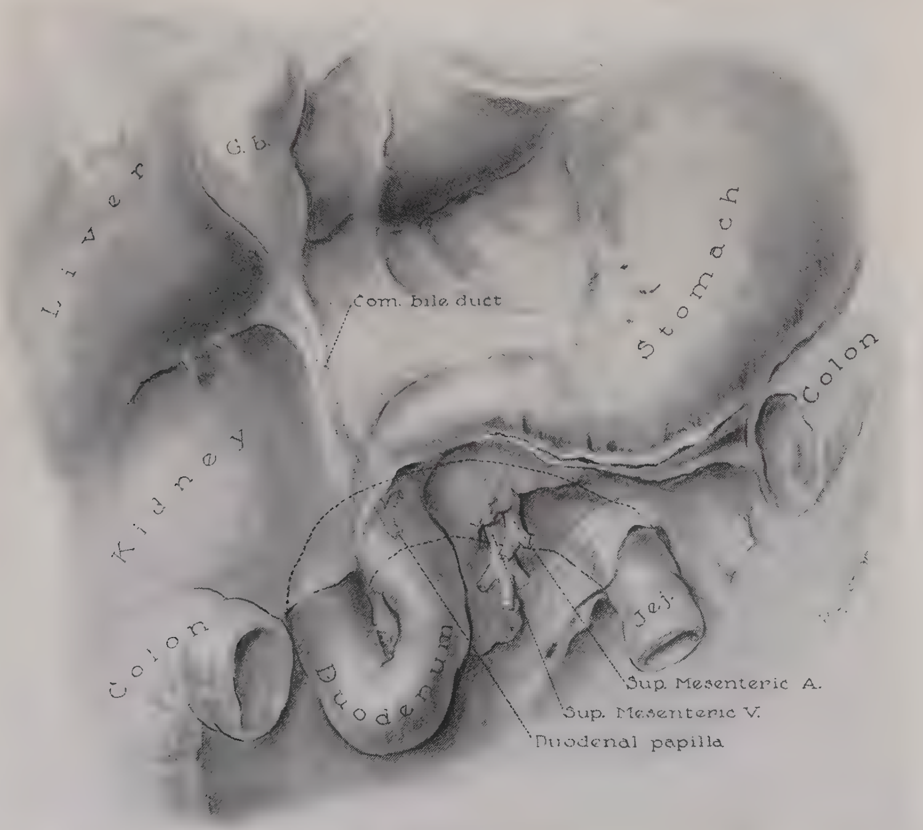
G. b.
Liver
Com. bile duct
Stomach
Colon
Kidney
Colon
Duodenum
Jej.
Sup. Mesenteric A.
Sup. Mesenteric V.
Duodenal papilla

Figure 1

There is nothing on record so far as the writer is aware that would suggest that this abnormal form may be clinically important. On the contrary, it appears to have been perfectly harmless. It is worth mentioning because it is embryologically interesting and because it is bound to come now and then to the attention of radiologists. Conceivably, a clinician may go back to his anatomical textbook in order to find out whether an observed (or suspected) anomaly has been described. To bring an occasional partial inversion of the duodenum to the attention of those anatomists who may be consulted, formally or informally, by their clinical colleagues, is one of the objects of this communication.

It is a pleasure to acknowledge the writer's indebtedness to Miss Ruth Coleman for preparing the illustration which is the mainstay of this note.

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SUCCESSFUL GRAFTING OF FROZEN AND THAWED MOUSE SKIN

ROBERT BRIGGS AND LOIS JUND
Lankenau Hospital Research Institute, Philadelphia, Pennsylvania, and Marine
Experimental Station of The Lankenau Hospital Research Institute,
North Truro, Massachusetts

ONE PLATE (FOUR FIGURES)

INTRODUCTION

During recent years several investigators have reported the successful transplantation of tumors of various types after freezing and thawing (Breedis, '42; Klinke, '39; Snell and Cloudman, '43; and others). The extensive study by Breedis on the resistance of leukemic cells to cold indicates that about 1% of the treated cells remain viable after freezing to − 70°C. or − 196°C.; and it is similarly possible that only a fraction of the cells of other types of neoplasms survive freezing and thawing in viable state. So far as we are aware there are no published data demonstrating that mammalial organs can survive freezing and thawing in functional condition. The likelihood that skin might do so is suggested by the work of Mider and Morton ('39) who used it as control material for freezing experiments with tumors. Pieces of rat skin were frozen at − 74°C., then thawed and implanted subcutaneously. Ten days later the implants were removed. Histological preparations revealed mitotic figures among the epithelial cells, which along with the general appearance of the sections indicated that the skin had survived in viable condition. No skin grafts proper were made so it could not be concluded from these experiments that the frozen and thawed skin remained functional.

Our own experiments, described in the following account, were designed to determine with certainty if mouse skin could survive freezing and thawing sufficiently well to resume permanently its function as skin when grafted to experimental defects in the skin of the animals from which it was originally taken. The proper solution of the problem required a dependable grafting technic for mice. A suitable method, giving under certain conditions practically 100% takes, was developed and is described herewith.

METHODS

In the course of developing our grafting technic we tried some of the methods described in the literature (Barker, '41; Boyd, '32; Reed and Sander, '37). Autoplastic grafts sutured into experimental defects on the back or belly of twenty adult dba mice and left unpatched dried up and formed scabs which were lost within 2 weeks. Similar grafts on twenty-eight dba mice were covered with various types of patches. The mice chewed or scratched away these patches, usually within a day after they had been applied, and the grafts then dried up and were lost within 2 weeks.

In an attempt to prevent the desiccation of the graft before it became vascularized we implanted small grafts about 2 to 3 mm. in diameter beneath skin flaps on the back or belly of twenty-nine C_3H mice 8 to 10 weeks old. Dorsal-ventral autoplastic transfers were used so that successful grafts might be recognized by the type of hair growing from them. When the protecting flaps were removed 7 to 19 days postoperatively the grafts were found to be surrounded by connective tissue and had undergone degenerative changes in varying degrees — an observation also made by Boyd ('32) on similar grafts of mouse skin. Ten out of twenty-nine grafts (35%) survived and grew hair characteristic of the donor site. This is a much smaller percentage of takes than Barker ('41) obtained using a similar method with guinea pigs. Barker did not mention that his grafts were affected deleteriously by being covered with skin flaps for 14 to 19 days, and it may be that guinea pig skin survives this treatment better than mouse skin does.

The method that finally gave satisfactory results is similar to an unpublished technic devised by Thigpen for baby mice. As worked out by us for older animals it involved the following steps. The mouse was anaesthetized with 0.6% nembutal injected into the body cavity (about 0.2 ml. per 10 gm. body weight). The hair was then clipped from an area extending completely around the middle of the body. Areas to be grafted were the middle of the belly, just posterior to the xiphisternum, and the middle of the back in the lumbar region. These areas were swabbed with 70% alcohol, wiped dry, and marked with no. 6 cork borer previously dipped in an aqueous solution of neutral red. This system of marking enabled us to cut out grafts of uniform size, 9.5 to 10 mm. in diameter. If a dorsal-ventral transfer was to be made the dorsal skin was cut out first with fine scissors and placed in a Petri dish on filter paper moistened with mammalial Ringer's solution. The ventral skin was then cut out, transferred directly to the dorsal defect, spread out, and fixed in place with a continuous fine silk suture (fig. 1). The dorsal skin was then grafted to the ventral defect in the same fashion. In some cases the order of grafting was reversed. After the grafts had been sutured each was covered with a patch consisting of cellophane next to the graft and adhesive tape overlapping the cellophane. These patches in turn were protected by a double thickness of adhesive tape, about 18 mm. wide, applied tightly and extending completely around the animal's middle. Operated animals were placed in small individual cages and kept warm in an incubator at 28°C. until they recovered from the anaesthetic at which time they were put back in the colony.

Five days after the operation the mice were anaesthetized again with nembutal. The band of adhesive tape and the patches covering the grafts were carefully removed and the sutures taken out. Usually the surface of the graft was slightly moist and covered with a thin superficial layer of dead tissue. When this tissue was dissected away the hair of the graft came with it. The graft itself had the color and consistency of normal skin indicating that it was already vascularized. Such grafts always persisted. In the course of 1 to 2 weeks hair began to grow from them. This hair had the color, length, and texture characteristic of the hair of the donor area. The grafts were usually rotated 45° to 180° when they were put in place, and the hair grew accordingly at an angle different from that of the adjacent hair of the host area. Occasionally the hair growing from grafts contained little or no pigment, but it could still be definitely identified as graft hair on the basis of its length, texture, and direction of growth.

The experiments reported on here were done with three inbred strains of mice. The dba and C_3H mice were from our laboratory colony; the CFl albino mice were obtained from Carworth Farms Inc., New City, N. Y.

RESULTS

Autoplastic grafts of normal skin

I. Autoplastic grafts of ventral skin to the dorsum in young mice (3 to 5 weeks old). Forty-two grafts of this type were made and observed for 7 to 22 weeks following the time of grafting. Table 1 (group I), summarizing the results, shows that forty grafts took completely while two grafts were partial takes in that more than 50% of the grafted skin survived. There were no failures (fig. 2).

Twenty-three of these grafts were made according to the technic outlined in the preceding section of this report. To test whether or not the suturing of grafts is a necessary part of the procedure we made twelve grafts without sutures, the other steps in the method being carried out as usual. Ten of these grafts were complete takes and two partial takes, indicating that suturing may not be necessary for well fitted grafts in young mice.

In another group of five animals the construction of the patch covering the graft was altered to allow for some evaporation from the graft surface, since we suspected that the accumulation of moisture under a tight patch might account for the necrosis of the superficial layers of the graft noted on page 77. In the cases in question the patch consisted of cellophane next to the graft and adhesive tape overlapping the cellophane on the lateral and posterior sides, but not on the anterior side. When these patches were removed at the end of the usual 5 days the grafts were found to be in excellent condition with little or no necrosis of the superficial layers. Thus it would appear that the best type of patch is one which prevents the graft from drying, but at the same time allows for enough evaporation to prevent the accumulation of moisture on the graft surface.

TABLE 1

Autoplastic grafts of normal mouse skin.

GROUP	TYPE OF GRAFT	AGE OF MICE — WEEKS	TOTAL NO. OF GRAFTS	COMPLETE TAKES	PARTIAL TAKES		% TAKES (COMPLETE + PARTIAL)
					> 50%	< 50%	
I	Ventral skin to dorsum	3 to 5	42	40	2	0	100
II	Dorsal skin to venter	3 to 5	34	9	9	9	79
III	Ventral skin to dorsum	8½ to 10	19	7	6	1	74
IV	Dorsal skin to venter	8½ to 10	19	0	0	10	53

II. Autoplastic grafts of dorsal skin to the venter in young mice (3 to 5 weeks old). Our results with this type of graft are summarized in table 1, group II. Thirty-four grafts were made and observed for 7 to 22 weeks. Of these seven failed completely, eighteen were partial takes, and nine complete takes — a result that compares unfavorably with that obtained with grafts of ventral skin to the dorsum. We observed the animals after the patches were removed from the grafts and found that they clawed and chewed at grafts located on the belly but left those located on the back undisturbed for the most part. This may account for many of the failures among grafts of dorsal skin to the venter. The relative thickness of the dorsal and ventral skin may also be important in grafting. The dorsal skin, being the thicker, is probably vascularized more slowly and is thus more likely to undergo degenerative changes before a blood supply is established. Figure 3 shows a successful graft of dorsal skin on the belly of a CF1 mouse.

III. Autoplastic grafts on adult mice. Thirty-eight grafts were made on nineteen adult C_3H mice, $8\frac{1}{2}$ to 10 weeks old. These were observed for 14 to 26 weeks. Table 1 (groups III and IV), summarizing the results, shows that grafts of ventral skin were more successful than those of dorsal skin, and that neither did as well as corresponding grafts on young mice 3 to 5 weeks old. These grafts on C_3H adults were among the first that we did, and our lack of experience at that time may have accounted partly for the fact that the results were not so satisfactory as those obtained later with young mice. However, the young mice have a thinner skin and a more rapid healing rate, and are to be preferred for grafting experiments unless there is some special reason demanding the use of mature mice.

Autoplastic grafts of frozen and thawed skin

Recent studies (Breedis, '42; Snell and Cloudman, '43; and others) have shown that several types of tumors survive slow freezing well, but are injured or killed by fast freezing. In particular, Breedis has demonstrated for leukemic cells a critical temperature range between 0°C. and − 15°C. If the fall in temperature through this range occurs in 12 seconds or less the leukemic cell suspensions are completely inactivated. If it occurs in 1 minute or more the suspensions remain infectious. The rate of thawing was found to have no influence on the survival of two of the three strains of leukemic cells used. The third strain was injured less by fast thawing than by slow thawing. Essentially the same results were reported earlier by Breedis and Furth ('38) for mouse sarcoma and carcinoma as well as for leukemic cells.

Methods. In our experiments with mouse skin the freezing was done slowly and the thawing rapidly according to the following methods: In expermient 1 the skin, immediately after being excised, was spread dermis side down on a piece of Whatman no. 1 filter paper previously moistened with mammalial Ringer's solution. This paper, about 17 mm. square, was then inserted into the bottom third of a 125 mm. × 15 mm. test tube in such a fashion that there was no contact between the wall of the tube and the skin, or the part of the filter paper upon which it rested. The tube carrying the skin was in turn fitted into the center of a larger tube, 120 mm. × 29 mm. The skin was frozen when this double tube assembly was placed in a thermos jug and surrounded by pulverized dry ice. Under these contitions the temperature at the center of the inner tube, as read with a mercury thermometer, dropped through the critical range (0°C. to − 15°C.) in 1.75 to 2.2 minutes. The skin remained frozen at the temperature of dry ice (− 78.5°C) for periods ranging from 1 hour to 24 hours. When the host was ready to receive the graft the inner tube was transferred from the dry ice directly into a water bath at 30°C. The skin appeared to thaw in 1 minute or less after which it was taken from the tube and grafted in the usual way.

In experiment 2 the freezing procedure was altered slightly. The skin, after being excised, was folded with the epidermis side out and placed without any additional treatment into the bottom of a dry 115 mm. × 10 mm. test tube. This tube was placed inside the double tube assembly described above. The temperature in the center of the innermost of the three tubes dropped from 0°C. to — 15°C. in 2.5 to 3.0 minutes. The skin remained frozen at — 78.5°C. for 1 to 6 hours. It was then thawed and grafted as in experiment 1.

In experiment 3 the freezing and thawing was altered at two points from that followed in experiment 2. The skin, within the small tube, was first placed in ice water for 15 to 35 minutes before being frozen in dry ice in the triple tube assembly. After 1 to 2 days we thawed the skin very rapidly by pouring Ringer's solution at 25°C. directly onto it.

All of these experiments were carried out with ventral skin of young mice, 3 to 5 weeks old. In experiments 1 and 2 we followed our usual technic in grafting the frozen and thawed skin autoplastically to dorsal defects. In experiment 3 the ventral skin grafts were carefully fitted into the dorsal defects and patched without sutures. To obtain accurate fits for sutureless grafts we had to take into account the retraction of wound edges that occurs right after a piece of skin is cut out. By cutting out circular pieces of dorsal skin about 8 mm. to 8.5 mm. in diameter we made defects that fitted 10 mm. grafts quite accurately.

Results. Table 2 summarizes our results with grafts of frozen and thawed skin. Out of a total of forty grafts twenty-one (52%) succeeded wholly or in part. The general history of these grafts ran as follows: When they were uncovered at 5 to 9 days after the operations eight grafts had already failed. They were white or yellowish-white in color, indicating that they had not been vascularized. The remaining thirty-two grafts were healed into the experimental defects in the host skin, and varied in color from a normal pink to white with a slight pink cast. Eleven of the pale, poorly vascularized grafts dried up and formed scabs within a week. Of the remaining twenty-one grafts fourteen were partial takes and seven complete takes. Sixteen to 25 days following the operations these grafts began to grow hair characteristic of the donor area. They were observed for 10 to 21 weeks. At the end of this period they were still intact (figs. 3 and 4).

The differences in the success of grafts in the three experiments listed in table 2 may be significant. The principal difference in technic between experiment 1 and experiment 2 was the omission in experiment 2 of any contact of the graft with physiological salt solutions. Thus there was less water associated with the graft, fewer ice crystals formed when the graft was frozen, and presumably less damage was done. Also, in experiments 2 and 3 the patches were left on the grafts for 6 to 9 days following the operations compared with a period of 5 days in experiment 1. Frozen and thawed grafts may be vascularized more slowly than normal ones, and probably should be protected from injury and desiccation for a longer period.

The best results with frozen and thawed grafts were obtained in experiment 3. This may be attributable to the fact that the grafts were thawed more rapidly in this experiment than they were in experiments 1 and 2. The preliminary cooling given the grafts before they were frozen is probably not important. Snell and Cloudman ('43) found that the resistance of mouse tumors to damage by freezing was not affected by a preliminary cooling from body temperature to 0°C.

TABLE 2

Autoplastic grafts of frozen and thawed ventral skin to the dorsum. Young mice, 3 to 5 weeks old.

EXP. NO.	TOTAL NO. OF GRAFTS	COMPLETE TAKES	PARTIAL TAKES		FAILURES	% TAKES (COMPLETE + PARTIAL)
			> 50%	< 50%		
1	18	1	3	2	12	33
2	13	2	3	3	5	62
3	9	4	1	2	2	78
Totals	40	7	7	7	19	52

Storage of skin in cold. The foregoing section of this report shows that skin can survive freezing and thawing but that, under our experimental conditions, it must be damaged somewhat since it does not graft as well as does untreated skin. There have been reports that tissues, organs, or whole embryos may be stored in transplantable condition for 1 or more days at temperatures just above freezing (Greene, '43; Michaelis, '05; Stone, '43). It seemed possible, therefore, that cold storage might be more suitable than freezing for preserving skin in viable conditions for short periods of time. To test this possibility we stored pieces of ventral skin from twenty young CFl mice (4 to 5 weeks old) at approximately 0°C. for periods ranging from 5 to 20 days. Each piece of skin was folded with the epidermis side out and placed in the bottom of a dry 19 mm. × 50 mm. vial. A roll of filter paper soaked with Ringer's solution was inserted into the neck of the vial which was then tightly corked and stored in a thermos jug containing ice cubes. When removed from storage the skin appeared to be quite normal. However, the majority of the grafts of stored skin failed. Two of five grafts stored for 5 days succeeded, one completely and one partially, and there were two complete takes from four grafts of skin stored for 10 days. Five grafts that were stored 14 days, and six stored for 20 days all failed.

DISCUSSION

The literature on the effects of freezing on plant and animal cells has been reviewed by Breedis ('42), Heilbrunn ('37), Maximow ('29), and others. There has been some disagreement as to whether cells are damaged more by slow or fast freezing, but recent work shows that many tumor cells at least survive slow freezing better. Accordingly, in all of the experiments reported here mouse skin was frozen slowly, and was demonstrated by grafting to have survived in an appreciable number of cases in functional condition.

From the literature it appears that a number of factors may be involved in resistance to cold. In the case of slow freezing ice forms intercellularly and water is withdrawn from the cells as the ice crystals grow (Chambers and Hale, '32; Maximow, '29; Stiles, '30). At temperatures only a few degrees below the point at which the intercellular ice is formed the cells themselves may not actually freeze, and survival may depend largely on their capacity to undergo reversible dehydration. However, when cells are frozen at very low temperatures survival must depend on other factors in addition to capacity to survive dehydration. Of these the "bound" water content of cells and hydrophilic gels has received considerable attention. Moran's ('26) experiments on discs of gelatin gel show that during slow freezing ice forms only on the outside of the gel. As the temperature is lowered water is removed from the gel until at − 19°C. it contains about 35% water. Below this temperature the gel will give up no additional water, and will not freeze even at − 190°C. In many plants there is evidence that the development of resistance to frost involves, among other changes, quite striking increases in bound water content (see review by Maximow, '29; also Levitt and Scarth, '36, and others).

We have examined some of the literature on mammalial skin to see if any of its properties can account for its capacity to survive freezing and thawing. Living skin can undergo considerable change in its water content (Eichelberger, Eisele, and Wertzler, '43; Kudo, '21; Skelton, '27) and thus should be capable of surviving the dehydration which freezing produces. There appear to be no data on the bound water content of skin. However, microdissection experiments indicate that the cytoplasm of the epithelial cells has the consistency of a tough jelly (Chambers and Renyi, '25) which might be an unfavorable site for ice crystal formation (Heilbrunn, '37). Analyses of whole skin show that most of its protein N is in the form of collagen (Eichelberger, Eisle, and Wertzler, '43; Lowry, Gilligan, and Katersky, '41). Collagen appears to absorb water in the same way (intramicellarly) that its product, gelatin, does (Halle, '34) and may hold much of it in unfreezable condition. These properties of skin may account in part for the fact that it is one of the organs best preserved by the freezing-drying technic (Gersh, '32), and for its capacity to survive freezing and thawing in functional condition as demonstrated in our experiments.

SUMMARY

1. Ventral skin from mice 3 to 5 weeks old remains viable after slow freezing to — 78.5°C. and rapid thawing to 25°C. or 30°C. When the thawed skin is grafted autoplastically 52% of the grafts take wholly or in part, and persist as functional skin.

2. Ventral skin from young mice, stored unfrozen at 0°C. for 5 to 20 days, has the appearance of normal skin but in the majority of cases fails to take when grafted autoplastically. Two of five grafts stored for 5 days, and two of four grafts stored for 10 days, were grafted successfully. A total of eleven grafts stored for 15 and 20 days all failed.

3. A skin grafting procedure is described which produces 100% takes of ventral skin grafted autoplastically to the dorsum in young mice (3 to 5 weeks old). Autoplastic grafts of dorsal skin to the venter in young mice take wholly or in part in 79% of the cases. Grafts of both types appear to take less rapidly in mature mice, 8½ to 10 weeks old.

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PLATE 1

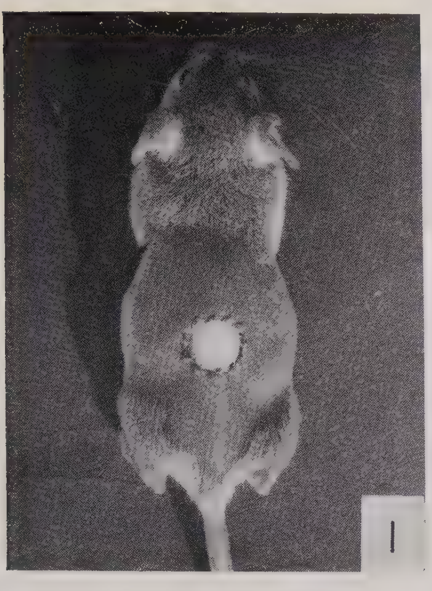
EXPLANATION OF FIGURES

1 Appearance of newly made graft of ventral skin on the dorsum of a C_3H mouse, 5 weeks old. Photograph taken immediately after grafting and before the protective covering was applied to the graft area.

2 Appearance of an autoplastic graft of normal ventral skin on the dorsum of a C_3H mouse 12 weeks after grafting. The color, length, and direction of growth of the graft hair distinguish it from the adjacent hair of the host area.

3 CFl albino mouse with autoplastic graft of normal dorsal skin on the venter. Less clearly shown on the dorsum is an area of short ventral hair growing from a successful autoplastic graft of frozen and thawed ventral skin. Photograph taken 14 weeks after grafting.

4 Autoplastic graft of frozen and thawed ventral skin on the dorsum of a C_3H mouse. Photograph taken 9 weeks after grafting.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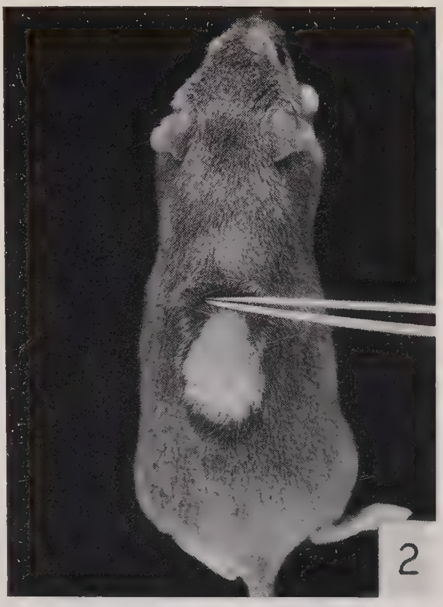
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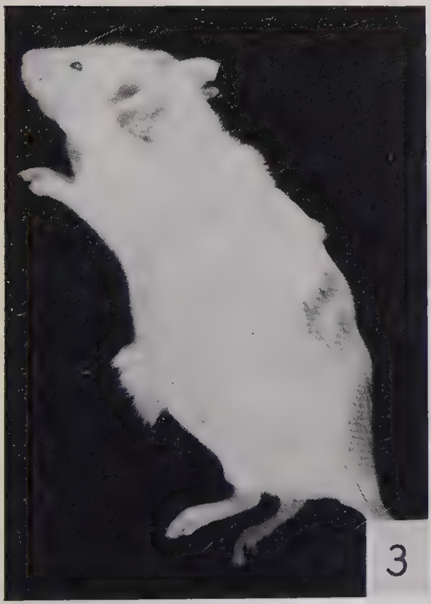
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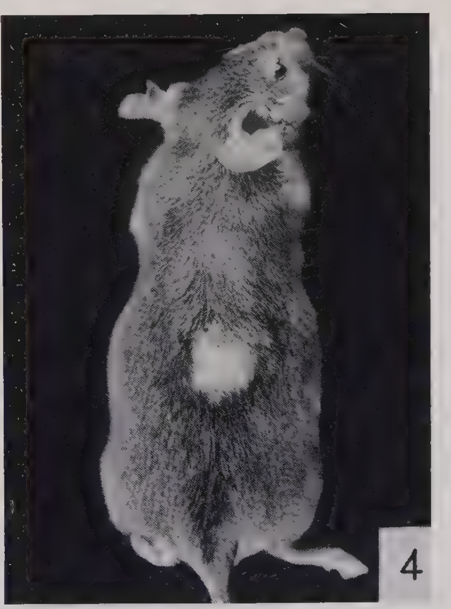
4

APICAL PERICARDIAL ADHESION RESEMBLING THE REPTILIAN GUBERNACULUM CORDIS

W. MONTAGUE COBB
Department of Anatomy, Howard University, Washington, D. C.

ONE PLATE (THREE FIGURES)

THE CASE

The gubernaculum cordis is familiar as a fibrous band covered with serous membrane which attaches the apex of the heart to the pericardium in turtles and crocodiles. It is considered to represent survival of a portion of the ventral mesocardium (Kingsley, '17). There is no record of the persistence of the mesocardia in man and it has become accepted as a mammalian peculiarity that no ventral mesocardium appears in this class because coalescence of primordial coelomic spaces creates a complete cavity beneath the cardiogenic plate before the heart begins to differentiate (Arey, '40). The following case is reported because of its striking resemblance to the reptilian structure and the interest of its probable pathologic origin. The author was not able to find similar examples in the literature.

Subject. The anomaly shown in figures 1, 2 and 3 was found in the course of routine dissection in this laboratory on October 30, 1935. It was immediately photographed in situ and careful descriptive notes were made. The cadaver was a male Negro (H.U. 71), stated to have been 71 years old, an age compatible with the condition of the skeleton, and a chauffeur by occupation. Pulmonary tuberculosis was the cause of death.

Band. The apex of the heart was joined to the mediastinal pericardium at its junction with the diaphragmatic portion by a broad, flat band of what appeared to be muscular fibers invested with a serous covering continuous above with visceral and below with parietal pericardium (figs. 1, 2). There was no evidence of current inflammatory process or exudate in the pericardial cavity or sac.

The band was 21 mm. broad at its cardiac attachment and 13 mm. broad at its pericardial end. It extended from above downward, forward and lateralward at an angle of about 42° with the midline. The medial border of the band was 22 mm. in length and the lateral border 26 mm. Shortest distance between cardiac and pericardial attachments was 19 mm. on the costal (ventral) surface; greatest distance 48 mm. on the phrenic (dorsal) surface. Thickness of the band was fairly uniform and measured 4 mm. near its cardiac end. The direction of the strands from heart to pericardium was nearly parallel to the surface of the mediastinal sac. Consequently, the costal surface of the band blended with the pericardium higher than the phrenic surface and was shorter than the latter.

The anterior descending branch of the left coronary artery with the great cardiac vein curved on to the diaphragmatic surface of the heart at the medial border of the band, some of the fibers of the latter apparently passing beneath the vessels. Cardiac attachment specifically to the left ventricle was thus delimited.

Microscopic examination of a longitudinal segment of the band by Dr. R. L. McKinney did not reveal muscular fibers within it.

Heart. The heart itself was small. The apex lay 15 mm. lateral to the left border of the sternum in the fifth interspace. The right border of the heart at furthest projection was 25 mm. beyond the right border of the sternum. Transverse breadth of the organ in situ was 81 mm. and vertical height 103 mm. Lateral displacement to the right was presumably a result of fluid in the lower left chest. Slight coronary sclerosis was grossly apparent.

When the pericardial sac was opened, the diaphragmatic surface of the heart did not rest upon the parietal pericardium, but was separated from the latter by a space of about 19 mm.

Lungs and pleurae. The lower left chest presented a large pleural cavity which apparently had been filled with fluid, as much caseous matter was found in its dorsal recess. This open pleural space ended above in the fifth interspace just lateral to the mid-clavicular line. Costal and mediastinal pleurae were much thickened.

The left lung had been markedly compressed or collapsed below and was 45 mm. from the chest wall in the mid-axillary line at the level of the seventh interspace.

The upper lobe of the left lung was merely a shell for an enormous multilocular cavity. A large cone-shaped cavity 40 mm. in depth in the upper dorsal portion of the lower lobe had its base directly adherent to the chest wall. Additional cavities were present in the left lower lobe.

No cavitation was present in the right lung but nodules apparently tuberculous were present in each lobe.

DISCUSSION

The well developed condition of the gubernaculum cordis in the Chelonia and Crocodilia has been long known (Owen, 1866) and well illustrated (Fabian, '13; O'Donaghue, '18; Abbott, '36). It appears to be an anchoring device and in the physiological laboratory has proven a great convenience for the attachment of hooks or clamps by which the heart might be manipulated. Its ventral mesocardial origin seems uncontested.

The location, form and serous investment of the present structure presented sufficient resemblance to the reptilian gubernaculum to require the possibility of similar origin to be critically examined. Old text-figures of a human ventral mesocardium still used (Prentiss and Arey, '23; Arey, '40) indicate how such an origin might be postulated. The evidence presented, however, by those investigators who have affirmed that a ventral mesocardium is not formed in mammals and particularly in man (Robinson, '03; Rouvière, '04; Yoshinaga, '21; Davis, '27), seems so clear that a developmental origin for the condition in our specimen must be considered an extremely remote possibility, if it may not be dismissed entirely. It should be mentioned though, that if two of the primordial coelomic spaces from which the pericardial cavity is formed, should fail to coalesce under that portion of the cardiogenic plate which would develop into the apex of the heart, but simply remain in juxtaposition, a septum would result which might give rise to the band in our case.

A pathological explanation is more plausible. In view of the size of the band and the fact of its coverage with serous membrane, it might be assumed to be an old apical pericardial adhesion which in the course of time became stretched and developed to present dimensions by cardiac contraction.

In the absence of clinical history the most obvious possible cause of such an adhesion would be extension of the tuberculous process in the left lung which had attained massive proportions at death.

SUMMARY AND CONCLUSION

A serous-covered fibrous band uniting the apex of the heart to the pericardium in an aged male has been described and its resemblance to the gubernaculum cordis of certain reptiles indicated. After consideration of factors involved in postulating either developmental or pathological origin, it was concluded that the structure is the result of an old pericardial adhesion which became stretched and expanded by cardiac contraction. The adhesion itself appeared to have been caused by extension of tuberculous pathology in the adjacent lung. The writer is grateful to his colleague in pathology, Dr. Robert S. Jason, for a critical reading of this report.

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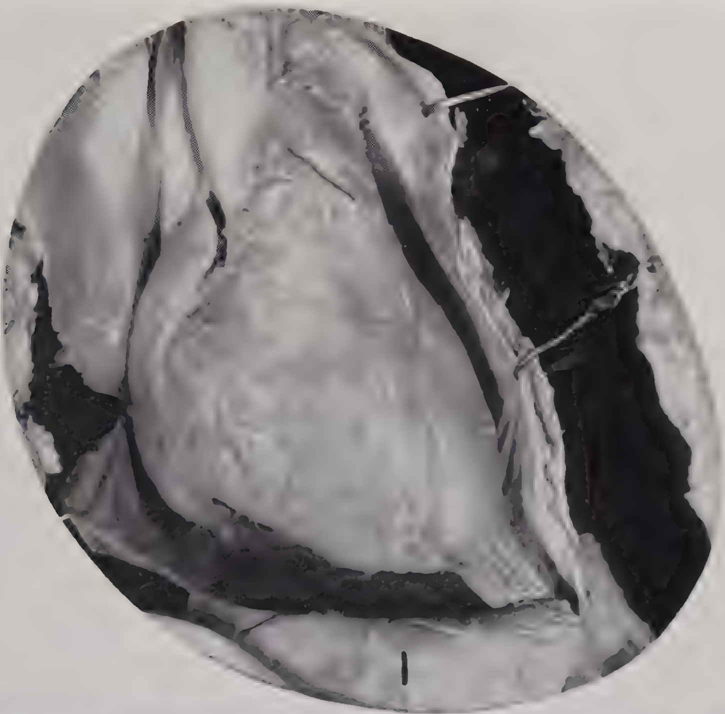
PLATE 1

EXPLANATION OF FIGURES

1 Heart in situ from in front. The pericardial sac has been opened and retracted showing costal surface of the apical band attaching heart to pericardium.

2 Diaphragmatic surface of heart showing phrenic surface of band. The continuity of the serous coat of the band with that of visceral pericardium above and parietal pericardium below is clearly shown. Band fully extended.

3 Same view as figure 2. Tension on band relaxed so as to show higher blending of costal than phrenic surface with pericardium.



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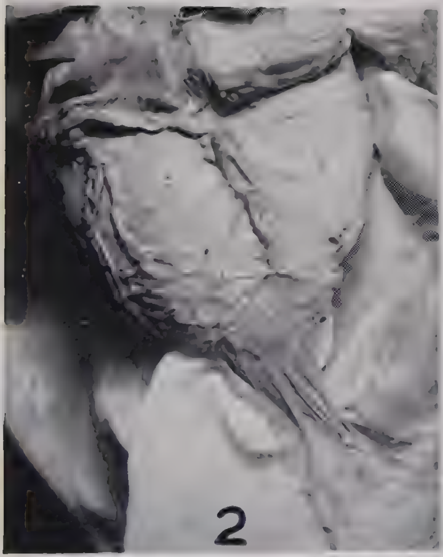

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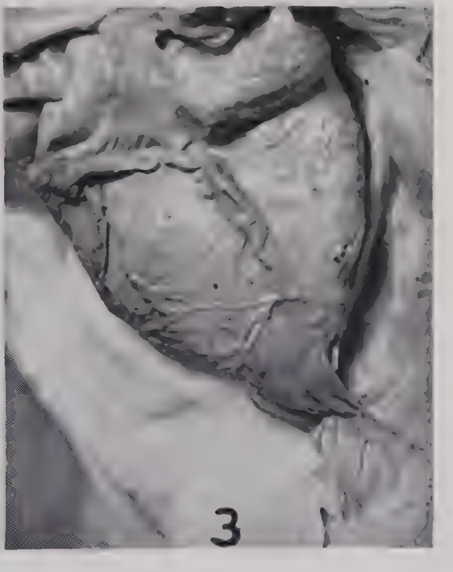

3

A COMPARISON OF THE INJECTION AND RED-CELL STAINING METHODS USED IN QUANTITATIVE STUDIES OF THE CAPILLARIES OF THE CENTRAL NERVOUS SYSTEM

STANLEY P. DRUMMOND[1]
Department of Zoology, University of Toronto, Canada

TWO FIGURES

For the quantitative study of the capillaries of the central nervous system there are, in general, two methods available — the injection method, and the staining method. A great deal of research has already been done in this field by both methods.

The injection of a colored gelatine mass into the vascular system has been used by Craigie in a long series of studies on amphibian, reptilian, avian and mammalian brains (Craigie, '20, '21, etc.), by Pfeifer ('28, '30), by Dunning and Wolff ('37) and by Scharrer ('39). Cobb and Talbott ('27) used the injection of a berlin-blue solution. Campbell ('38) developed a method of staining the blood plasma, which he called the "vital staining method". It consists in the intravenous injection of a non-toxic dye, such as Chlorazol sky blue, before killing the animal.

The staining method demonstrates the vascular bed by staining either the capillary walls or the red-cells within the capillaries, after the specimen has been fixed and sectioned. Lorente de Nó ('27) used the Golgi-Cox method to stain the capillary walls. The red-cell staining method, originally used by Lepehne ('19), has developed into a number of different techniques. The iron haematoxylin stain was used by Craigie ('29), the Morgan stain by Cobb ('31), the Weigert-Pall method by Pfeifer ('31) and Eckstein ('35) and the Nissl and Masson stains by Scharrer ('39). Variations of the benzidine stain have been employed by Pickworth ('34, '37), Sjöstrand ('34), Petrén ('38a, '38b), Alexander and Putnam ('38), Campbell, Alexander and Putnam ('38), Doherty, Suh and Alexander ('38).

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[1] Loyola College, Montreal, Canada.

Both methods have one defect in common (Craigie, '20; Pickworth, '34). All vascular research has its limitations, since death intervenes between the living condition and post-mortem examination. We have no way of telling how great are the postmortem changes in cerebral tissues and their related blood vessels, or whether our material represents the living condition or not.

Each method has its own particular defects. The same is true of the individual variations of either method. The value of the injection method has been seriously questioned by Pickworth ('34), Campbell ('38), Lindgren ('40) and others. Craigie himself ('20) pointed out some of the main defects of this method, which can be reduced to five.

First, there is the possibility of an incomplete injection of the entire capillary system. This danger can be minimized by discarding all specimens showing evidence of incomplete injection and by cutting every eleventh section at 200 μ. The completeness of the injection can be examined by the method of Pfeifer ('28) in these thick sections and presumed in the ten adjacent sections in which the actual measurements are to be made. Secondly, there is the possibility of the reflex effect of the injection agents upon the vasomotor mechanism and the walls of the capillaries, which may cause them to dilate or constrict abnormally. Thirdly, the shrinkage that occurs in the injection mass may yield results that are not representative. Fourthly, the effect upon the capillaries of the pressure used for the injection. This difficulty has been studied by Craigie ('30, '38, '41), who concludes from a wide range of pressures used, that any variations recorded in the diameters were not related to the pressure used. Fifthly, there is the possibility of injecting capillaries which might have been closed in the living animal at the time of death. This last defect is, of course, difficult to evaluate, since it is not at all definite whether or not the cerebral capillaries are actually capable of opening and closing as they are in other tissues of the body. Many authors maintain they are not. However, there is a limited amount of evidence (Cobb and Talbott, '27; Talbott, Wolff and Cobb, '29) which indicates that in certain localized regions, at least, there is an opening and closing of cerebral capillaries. Until more evidence is available, this difficulty must remain as a distinct possibility.

The red-cell staining method should, theoretically at least, be free from these defects of the injection method. Lindgren ('40) calls the blood the best injection fluid, and consequently the red-cell staining method should yield a picture of the blood in the vessels exactly as it existed in the physiological state of the animal at the time it was killed, or at least after such postmortem changes as might be caused by death, and which, being common to all methods, are beyond the control of the research. The most serious objection to the method is the possibility of loss of blood during the removal of the brain from the animal, or perhaps the possibility of an artificial distribution of the blood in the capillary bed as a result of the necessary handling of the brain in removing it from the animal. However, as Pickworth ('34) has pointed out, on account of the microscopic size of the capillaries, the mechanical force must be considerable before it causes a change in the vascular relationships.

It seems, then, that in spite of the arguments for or against either method, a final decision has not been arrived at in favor of one to the exclusion of the other. Undoubtedly each has its own merits, but the question under consideration is whether they are equally reliable or not. The only way to solve the doubts that have been raised, is to institute a direct comparison between the results obtained by both methods, when employed on the same species under as nearly as possible the same conditions. Such a comparison ought to afford a crucial test of their respective values. This is being done in the present study and will complete for the first time a set of comparable figures of the vascularity supply of the brain obtained on the same species by the two different methods.

MATERIAL

The material chosen was the brain of the leopard frog (R. pipiens). Dr. Craigie has most kindly placed at the disposal of the author his material prepared by the injection method, as well as the use of the data previously reported by him (Craigie, '38). The material for the study of the red-cell staining method consisted of the brains of twenty active leopard frogs. Ten specimens were chosen for the actual measurements of vascularity. Seven additional specimens were used to determine shrinkage measurements, but were not used for the actual measurements.

METHODS

All the animals were killed by anaesthetizing them with chloroform, then by immersing them in 20% neutral formalin (Sjöstrand, '34). In order to avoid any loss of blood during dissection, the brain was exposed in stages and returned to the fixative for further fixation before proceeding to the next stage. Thus, after death, the skin over the surface of the head was slit open and the entire animal placed in fixative for 6 hours to harden the surface vessels. Then portions of the fronto-parietal bones were removed over the cerebral hemispheres where there was less danger than elsewhere of damaging the vessels, after which the animal was fixed in toto for another 10 hours. Then the brain was completely exposed dorsally and laterally and fixed in situ for 12 hours. Finally the brain was removed from the animal and fixed for a final 12 hours. Any specimen in which loss of blood had been detected was promptly discarded.

All specimens were dehydrated in three changes of acetone, cleared in benzine and embedded in paraffin. The vacuum pump was used for a few minutes on each brain while in the paraffin bath in order to ensure complete impregnation of the tissues and cerebral ventricles. All specimens were cut into complete transverse series of 20 μ thickness. A few 200 μ sections were attempted in one series, but no further attempt was made due to the difficulty encountered in cutting such thick sections in paraffin. Three series were stained with orthotolidin hydrogen peroxide (Sjöstrand, '34), and lightly counterstained with erythrosin. The remaining series were stained with Weil's modification of the myelin sheath stain (Weil, '28). The change in staining was adopted because the latter stain, when over-bleached, gave the red cells a beautiful blue-black stain against a light fiber and cellular background, which facilitated the identification of the regions to be examined.

Measurements of the lengths and diameters of the capillaries were made by employing a square-ruled ocular micrometer after the method adopted for the injection material (Craigie, '20). In order to determine the length of capillaries in fresh tissue, a coefficient for correction for shrinkage was determined by measuring the three dimensions of the brains of seven frogs before fixation and again at the end of the paraffin bath. The coefficient was then determined by applying the formula published by Craigie ('24). It was found to be 0.8, the same as that obtained for the injected material (Craigie, '38). Likewise for the correction of the diameters of the fixed capillaries, the same shrinkage measurements were used to calculate the average linear percentage correction factor, which was found to be 12.2%.

To facilitate comparison, the term "summer frog" will be used to designate the specimens prepared by the red-cell staining method, while the term "injected frog" will represent the frog injected with carmine gelatine (Craigie, '38).

For the identification of the various tracts and nuclei in the brain of the frog which were studied in this paper, the following sources were consulted:

Black, '17.
Gaupp, '99.
Herrick, '21, '27, '30, '33a, '33b, '33c, 34a, '34b.
Johnston, '06.
Kappers, Huber and Crosby, '36.
Larsell, '23, '25, '34.
Papez, '29.
Röthig, '26, '27.

OBSERVATIONS

Lengths of capillaries

It was found that for the magnification used (540 ×) the volume of tissue covered by the ocular micrometer amounted to 208 × 208 × 20 cu. μ. As a general rule half this volume was employed since it gave reliable results. Measurements of the pieces of capillary were made in ten consecutive sections in each region, so that the total length of capillary was ascertained for a volume of tissue measuring $\frac{1}{2} \times 208 \times 208 \times 200$ cu. μ. This was the unit measured in every case except in the neuropil of both the primordium piriforme and the corpus striatum, pars ventralis. In these two regions the volume measured was 3/5 of a unit, and from this measurement the regular unit volume was calculated. For each region studied the whole procedure was repeated in ten specimens and the average taken. Finally, in order to obtain values for fresh brain tissue, the results were corrected for shrinkage by the use of the coefficient 0.8 mentioned above, and reduced to the length of capillary in 100 cu. μ of fresh brain tissue.

The results for the summer frog have been gathered together in tables 1 and 2, and in figure 1, in which the parts have been arranged according to the ascending order, the regions of the hindbrain being grouped together first, and those of the forebrain afterwards.

The results for the injected frog, though originally measured in a unit of $\frac{1}{2} \times 189 \times 189 \times 200$ cu. μ of fixed tissue, have been expressed in length per $\frac{1}{2} \times 208 \times 208 \times 200$ cu. μ of fixed tissue, using the data previously published (Craigie, '38). These have been included in tables 1 and 2, along with the corrected fresh measurements in figure 1, in order to compare the results of the two methods.

A study of tables 1 and 2 showed that in all areas, with six exceptions, the results were statistically the same. These six exceptions

TABLE 1

Capillary length in the hindbrain of the frog (Rana pipiens).
(Averages before and after correction for shrinkage, with probable errors).

LOCATION	SUMMER FROG			INJECTED FROG		
	Capillaries in $\frac{1}{2} \times 208^2 \times 200$ cu. μ of fixed tissue		Average length in 100^3 cu. μ of fresh tissue	Capillaries in $\frac{1}{2} \times 208^2 \times 200$ cu μ of fixed tissue[1]		Average length in 100^3 cu. μ of fresh tissue
	Average and P. E.	Per cent P. E.		Average and P. E.	Per cent P. E.	
Fasciculus longitudinalis medialis	498 ± 16	3.2	92	469 ± 11	2.4	87
Nucleus XII	644 ± 26	4.0	119	620 ± 21	3.4	115
Nucleus motorius dorsalis X	675 ± 19	2.8	125	646 ± 34[2]	5.2	119
Nucleus motorius V	683 ± 17	2.5	126	281 ± 27[2]	4.0	126
Cerebellum: granular layer	704 ± 44	6.3	130	695 ± 20	2.8	129
Nucleus fasciculi solitarii	765 ± 40	5.2	141	837 ± 21	3.0	155
Nucleus motorius VII	793 ± 38	4.7	147	619 ± 26[2]	4.2	114
Eminentia cerebelli ventralis	797 ± 27	3.4	147	900 ± 23	2.6	167
Nucleus spinalis V	836 ± 30	3.6	155	860 ± 16	1.8	159
Cerebellum: molecular layer	841 ± 32	3.8	155	792 ± 29	3.7	147
Nucleus ventralis VIII	871 ± 47	5.3	161	915 ± 28	3.1	169
Nucleus sensorius principalis V	921 ± 62	6.7	170	1332 ± 19	1.4	247
Superior olive	1333 ± 39	2.9	246	1750 ± 44	2.5	324
Nucleus dorsalis VIII	1911 ± 104	5.4	353	2234 ± 40	1.8	416

[1] Calculated from the original fixed volume of $\frac{1}{2} \times 189^2 \times 200$ cu. μ.

[2] Recent unpublished remeasurements made in the original material by the present writer.

TABLE 2

Capillary length in the forebrain of the frog (Rana pipiens).
(Averages before and after correction for shrinkage, with probable errors).

LOCATION	SUMMER FROG			INJECTED FROG		
	Capillaries in $\frac{1}{2} \times 208^2 \times 200$ cu. μ of fixed tissue		Average length in 100^3 cu. μ of fresh tissue	Capillaries in $\frac{1}{2} \times 208^2 \times 200$ cu μ of fixed tissue[1]		Average length in 100^3 cu. μ of fresh tissue
	Average and P. E.	Per cent P. E.		Average and P. E.	Per cent P. E.	
Nucleus dorso-lateralis amygdalae	506 ± 39	7.6	94	554 ± 22	3.9	103
Ventral corpus striatum	589 ± 26	4.4	109	584 ± 21	3.6	108
Primordium pallii dorsalis	754 ± 24	3.2	139	760 ± 21	2.8	141
Nucleus medialis septi	767 ± 41	5.3	142	824 ± 16	1.9	153
Primordium piriforme	784 ± 40	5.2	145	650 ± 37[2]	5.7	120
Neuropil of ventral corpus striatum	857 ± 25	2.9	158	960 ± 48[2]	5.0	177
Primordium hippocampi	871 ± 31	3.6	161	818 ± 23	2.8	151
Neuropil of primordium piriforme	1041 ± 52	5.0	192	761 ± 53[2]	6.9	141

[1] Calculated from the original fixed volume of $\frac{1}{2} \times 189^2 \times 200$ cu. μ.

[2] Recent unpublished remeasurements made in the original material by the present writer.

were the three nuclei of the motor column of the hindbrain; the piriform cellular and neuropil zones, and the neuropil of the corpus striatum, pars ventralis in the forebrain.

A remeasurement of these regions in the stained material substantiated the original figures given in tables 1 and 2. An examination of the injected material, however, showed that for each region, the levels originally measured by Craigie did not correspond with those chosen for the stained material. Consequently, in these six regions in the same injected material formerly employed, new measurements were undertaken at the same levels as those adopted for the stained material.

In the three forebrain regions (from an average of five specimens) the present writer found values corresponding with those for his stained material, the levels examined being farther forward than those previously studied by Craigie. Craigie then made a new set of measurements at these same levels in all ten specimens. The results produced averages which were more closely in line with those obtained in the red-cell stained material. These new, hitherto unpublished, figures (Craigie, '42) have been added to table 2 and figure 1, in place of the values formerly reported.

In the hindbrain regions, the present writer made a similar set of measurements in all ten specimens, at the same levels as those employed for the stained material. The results were more closely in agreement with those for the stained material, and as they have been examined and accepted by the original author as more representative than those previously reported by him (Craigie, '43), they have likewise been used in table 1 and figure 1.

Figure 1 shows that when the measurements are made at the same levels in each region, the results are substantially the same, whether they be obtained by the injection method or the red-cell staining method. It is to be noted that in the forebrain the areas of neuropil now assume a relationship different from that formerly reported (Craigie, '38). The neuropil of the primordium piriforme and that of the ventral corpus striatum are now significantly richer than their respective cellular zones, and appear to be the richest of the parts measured in the forebrain, a relation which exists in Ambystoma and Necturus (Craigie, '39, '40). Although the relative degree of vascularization is poorer in Ambystoma than it is in the frog, and poorest of all in Necturus, the neuropil in Amphibians is found to be among the most richly supplied of the areas thus far measured in the forebrain.

These observations "lessen considerably the force of the comments made in the previous report (Craigie, '38, p. 465) where the poverty of the neuropil was unfortunately stressed" (Craigie, '42). Herrick and others maintained that since the areas of neurpoil are composed of a great number of synapses and terminal arborizations, the metabolic activity of these parts should also be greater than that of the cellular or fiber areas, and that consequently they should be proportionately more richly supplied with blood. Dunning and Wolff ('36, '37) brought forth quantitative evidence to this effect, and the present results substantiate, in part, this contention.

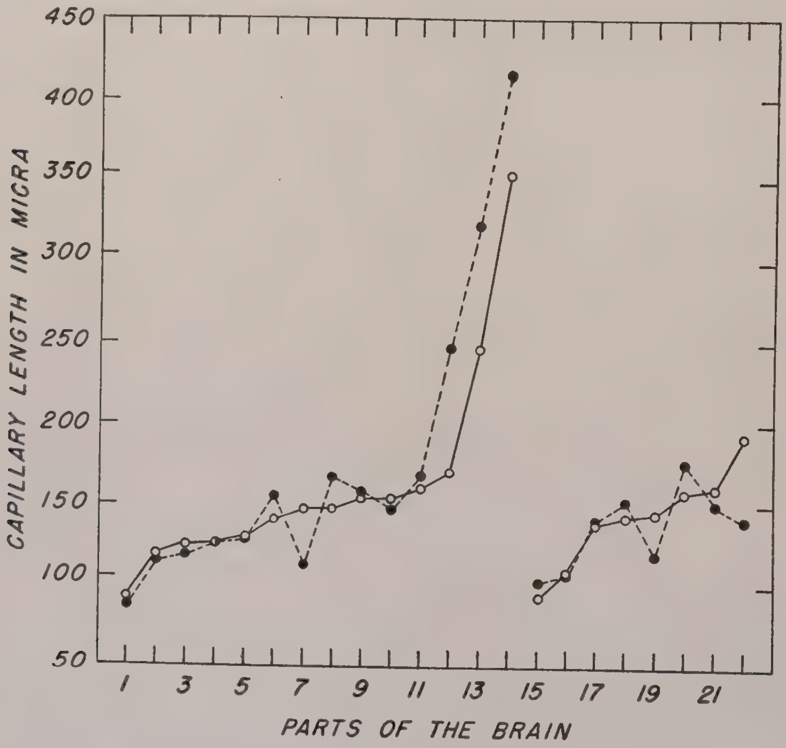

Fig. 1 Graph showing the capillary length in μ in 100^3 cu. μ of fresh tissue in 22 regions in the brain of the frog. ○, results obtained by the red-cell staining method; ●, results obtained by injection.

1. Fasciculus longitudinalis medialis
2. Nucleus XII
3. Nucleus dorsalis motorius X
4. Nucleus motorius V
5. Cerebellum: granular layer
6. Nucleus fasciculi solitarii
7. Nucleus motorius VII
8. Eminentia cerebelli ventralis
9. Nucleus spinalis V
10. Cerebellum: molecular layer
11. Nucleus ventralis VIII
12. Nucleus sensorius principalis V
13. Superior olive
14. Nucleus dorsalis VIII
15. Nucleus dorso-lateralis amygdalae
16. Ventral corpus striatum
17. Primordium pallii dorsalis
18. Nucleus medialis septi
19. Primordium piriforme
20. Neuropil of ventral corpus striatum
21. Primordium hippocampi
22. Neuropil of primordium piriforme

The molecular layer of the cerebellum is more richly supplied than the granular layer in both the stained and injected material, indicating the parallelism in the vascular supply of the molecular layer of the cerebellum and the forebrain neuropil that has been noted in other amphibians (Craigie, '39), though the parallelism does not extend to other classes of vertebrates studied (Craigie, '20; Dunning and Wolff, '37; Campbell, '39).

DIAMETERS

Measurements of the diameters of the capillaries were made in the same six regions of the brain stem and four regions of the forebrain of the summer frog as in the injected frog. In all, fifty capillaries were measured in each region in five specimens, and the averages taken.

TABLE 3

Capillary diameter in the brain of the frog. (Average diameter in μ before and after correction for shrinkage).

LOCATION	SUMMER		INJECTED	
	Fixed	Fresh	Fixed	Fresh
Fasciculus longitudinalis medialis	5.5	6.2	6.1	6.8
Nucleus XII	5.9	6.6	6.4	7.2
Cerebellum: granular layer	5.9	6.6	5.8	6.5
Nucleus motorius VII	5.8	6.5	5.5	6.2
Cerebellum: molecular layer	5.3	5.9	4.9	5.5
Nucleus dorsalis VIII	6.0	6.7	6.0	6.7
Ventral corpus striatum	5.3	5.9	5.6	6.3
Primordium pallii dorsalis	5.9	6.6	5.5	6.2
Neuropil of ventral corpus striatum	5.0	5.6	4.9	5.5
Primordium hippocampi	5.6	6.3	5.6	6.3
Average	5.6	6.3	5.6	6.3

These averages were then corrected for shrinkage by the application of the linear contraction factor of 12.2%, mentioned above. These figures have been gathered together in table 3, and plotted in figure 2. Again, the corresponding values for the injected frog (Craigie, '38) have been added for comparison.

The average diameter of all the capillaries in the stained material was found to be 6.3 μ for fresh capillaries, the same as that for the injected frog, in spite of variations in individual areas.

It will be noted how closely the values for the summer frog correspond with those for the injected frog, except for the fasciculus longitudinalis medialis and the nucleus of the hypoglossal nerve. In these two regions the capillaries are about 10% narrower in the summer frog, though the difference is of doubtful significance. The average diameter of the capillaries in the molecular layer of the cerebellum in both the stained and injected material is significantly smaller than it is in the granular layer.

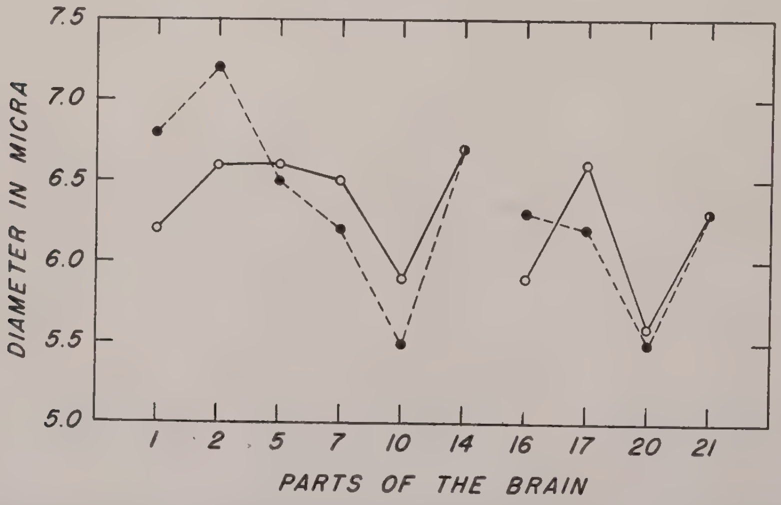

Fig. 2 Graph showing the diameters in μ of fresh capillaries in ten regions in the brain of the frog. ○, results obtained by the red-cell staining method; ●, results obtained by injection. The parts are numbered as in figure 1.

CONCLUSIONS

As a result of an exact comparison of the two methods, several conclusions can be drawn. Since most of the values for capillary length in the injected frog either agree with, or are higher than, those for the stained material, the argument against the injection method on the grounds of an incomplete filling of the capillaries is proven to be invalid.

On the other hand, the higher values found in some regions by the injection method do not necessarily prove that the injection mass filled some capillaries which were closed off in the intact animal. The reason is that when allowances are made for probable error, the differences are not so great as to statistically warrant such a conclusion.

Finally, the present results would seem to disprove the contention that the diameters in the injected material are proportional to the pressure used in the injection, since similar results were obtained for each region in the stained material. Evidently the injection does not produce any greater reflex effect upon the vasomotor mechanism of the capillaries than does the killing agent which alone was used on the stained material.

In the light of the present investigation, the objections brought against the injection method are not more serious than those admitted by the red-cell staining method. While each method has its own merits depending upon the purpose of the research, nevertheless for the quantitative study of the cerebral capillary bed, one method must be considered as reliable as the other until further investigation either substantiates or disproves such a conclusion.

SUMMARY

For the quantitative study of the cerebral capillary bed, two general techniques are employed — the injection method and the red-cell staining method.

An historical and critical analysis of both methods is recorded.

Measurements of both injected and stained capillaries were made in the brain of the leopard frog under as nearly identical conditions as it was possible to obtain, in order to test the reliability of these two methods and the validity of the objections raised.

The results for the injected material were obtained from the material and paper formerly published (Craigie, '38), along with some more recent findings in the same specimens, in some regions where the levels formerly studied differed from the corresponding levels used in the stained material.

The stained material was prepared by Sjöstrand's orthotolidin hydrogen peroxide method, or by Weil's modification of the myelin sheath stain, three series being stained by the former and the remaining series by the latter.

The average total length of the capillaries in a unit volume of tissue, when made at the same level in each region, was substantially the same, whether obtained by injection or by staining.

The regions of neuropil were found to be among the most richly supplied of those measured in the forebrain. Relative to other forebrain regions, the neuropil assumes a relation different from that formerly published for the frog, and is more in accord with known results for other amphibian neuropil.

The diameters of the capillaries in each region studied are not significantly different for either method, and the average diameter of all capillaries studied is the same for each — 6.3 μ for fresh capillaries.

Each method has its own special advantages for particular types of research, but when quantitative results are desired, the present report bears out the fact that in the present state of our knowledge and techniques, they may be reliably obtained either by the method of injection or by the red-cell staining method.

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A PIG EMBRYO WITH BIFID NOTOCHORD, BIAXIATE BRAIN AND PAIRED HYPOPHYSES

W. C. GEORGE[1]

Department of Anatomy, University of North Carolina, Chapel Hill

ONE TEXT FIGURE AND ONE PLATE (EIGHT FIGURES)

Studies based on spontaneously produced abnormalities of development and comparisons of them with normal embryos and experimentally produced modifications of development have contributed greatly to a clearer understanding of morphogenetic processes. Although it is only an isolated case, a pig embryo recently discovered in our class material presents such interesting anatomical features that it seems worth while placing its description on record. Taken in comparison with other previously reported specimens and established data, this embryo seems to offer interesting evidence on the causal relationships in the development of the region involved.

OBSERVATIONS

The specimen here reported is a pig embryo about 7 mm. in length with no observed external abnormalities. Approximately, the caudal half of the embryo is normal internally, but cephalad the notochord is bifid and there are other associated abnormalities giving evidence of partial internal twinning. The bifurcation of the notochord begins in the 265th section from the head end in a series of 444 sections cut 15 micra thick. The region of transition between the normal single and the double notochord occupies two sections. This is at the level of the tenth spinal nerve, i. e., at the lower border of the second thoracic vertebra. The cardiac end of the stomach and the caudal margins of the anterior limb buds are located at this level and it is twenty-nine sections caudad to the cephalic end of the mesonephros. A wax plate reconstruction shows that the paired chordae make an approximately right angle bend ventrally near the junction of the spinal cord and hind brain (at the cervical flexure), and the prongs terminate slightly caudal to, and near the mesial borders of, paired Rathke's pouches. Adjacent, laterally located, depressions in the floor of the forebrain are doubtless the beginnings of paired infundibular evaginations (fig. 8).

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In the neural tube, deviation from the normal is associated with the bifid notochord. The normal condition in the region of the single notochord is shown in figure 2. At the level of the beginning bifurcation of the notochord, the floor plate of the spinal cord begins to broaden (compare figs. 2–5), and further cephalad, with increased lateral divergence of the two prongs of the notochord, two floor plates are present with a median mass of nervous tissue between them (fig. 5). The wax plate reconstruction shows that paired lateral sulci and floor plates extend as far cephalad as the caudal margin of the mid-brain. As the two floor plates diverge laterally the nervous tissue between them increases in quantity. What begins as a scarcely discernible bundle of fibers becomes in twenty-five sections a considerable median bundle with neuroblasts added just dorsal to the fiber bundle. In the next seven sections there is a median nucleus from which the bundle of fibers extends longitudinally. After twelve sections another nucleus is reached occupying six or seven sections, followed by another fiber tract (commissure) of sixteen sections, and then another nucleus for about five sections. Here the cervical flexure of the spinal cord is reached. Changes in the plane of the sections from transverse to frontal in the portion of the embryo cephalad to the cervical flexure make more difficult the study of conditions in the floor of the brain, but a succession of fiber tracts and cell masses is distinguishable in the mid-ventral line as far cephalad as the mid-brain.

In the floor of the hind-brain the median nervous tissue is a mass of considerable size (fig. 9). From this mass two trunks of nervous tissue (figs. 1 and 8) invested with connective tissue extend ventrally between the notochordal prongs and terminate in the connective tissue adjacent to the epithelial lining of the primitive pharynx. The more caudal one (figs. 1, fac., and 8, f. n.) of these trunks arises near the middle of the myelencephalon, is about 125 μ long, and terminates in the connective tissue of the roof of the pharynx without the fibers leaving the epineurium. It lies in the mid-line between right and left facial nerves and probably should be interpreted as representing fused medial facial nerves of a partial dicephalus. The more cephalic trunk (figs. 1, trig., 7, 8, t. n.) is thicker and longer and lies between the cephalic ends of the notochordal prongs and between the paired

Rathke's pouches still more laterally. It consists chiefly of fibers irregularly disposed, but it contains some cells, which are more abundant adjacent to the point of origin, and it has a connective tissue sheath. This trunk of nervous tissue lies midway between the semilunar ganglia and presumably represents fused medial trigeminal nerves of the partial dicephalus. Just before it terminates in the connective tissue it is joined by a much smaller cord (fig. 1) of nervous tissue arising by three median trunks, or roots: one from the more cephalic portion of the hind-brain floor represents fused abducens nerves (fig. 1, abd.); one from about the middle of the mid-brain floor represents fused oculomotor nerves (fig. 1, ocul.); and one from the diencephalon midway between the paired infundibular anlagen (fig. 1, opt.). This latter is not identified. The only nerve fibers known to me that might possibly be expected to grow out of the ventral wall of the diencephalon are postulated efferent fibers of the optic nerve, experimentally demonstrated by Arey ('16) in certain fishes. In this specimen there are no median eyes and hence no afferent optic nerve fibers from the retina would accompany the efferent fibers arising in the medial halves of the diencephalon of this partial dicephalus.

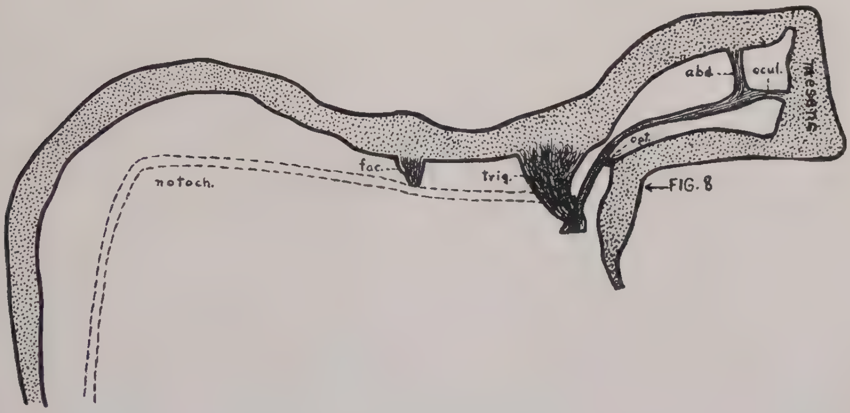

Fig. 1 Sagittal drawing (made from measurements of a wax plate reconstruction) of the ventral wall of a portion of the neural tube (stippled) and the median nerves emerging from it. Although they lie to the right and left of the median plane, the approximate position of a prong of the notochord is indicated. Also, the approximate plane of the section shown in figure 8 is indicated. abd.n, abducens nerve; fac., facial nerve; mesenc., mesencephalon; ocul., oculomotor nerve; opt., assumed efferent fibers of the optic nerve; trig., trigeminal nerve.

Intermingled with the fibers of the anomalous median oculomotor nerve in the floor of the mesencephalon are other fibers arising to the right and left of the mid-line. They decussate and pass out laterally from the ventral surface of the median thickened mass (fig. 9, tro. n.) into the connective tissue. They represent fused medial trochlear nerves of the dicephalus. Since the medial walls of the dicephalus brain are lacking, these fibers cannot pursue their normal course to the roof of the mesencephalon; hence they pass out of the wall of the midbrain on its ventral surface instead of dorsally. Laterally in this region the regular pair of oculomotor nerves was found originating in the walls of the mesencephalon and paired trochlear nerves were found emerging normally from its roof. No other anomalous cranial or spinal nerves were found.

The fact that the median nerves III, IV, V, VI and the questionable efferent optic fibers make contact with one another seems worthy of note.

The floor, and perhaps the roof, of the diencephalon is broader throughout than in normal embryos. Paired infundibular evaginations are widely spaced (fig. 8). More caudal paired recesses may represent mammillary recesses. Between the infundibular recesses there is a median thickening of the floor of the diencephalon extending as far forward as the optic chiasma. In the mid-line this mass shows longitudinally coursing fibers with evidence of alternating nuclear masses such as were described for the thickened median mass in the hind-brain and cord. From this median mass of fibers and nuclear material the nerve trunk arises which was originally spoken of as joining median nerves from the floor of the hind-brain and mid-brain, and interpreted as efferent fibers of the optic nerve.

Neither mesencephalon nor telencephalon show very pronounced differences from normal. Both show a somewhat greater transverse diameter, perhaps, than normal. The cephalic portion of the floor of the mesencephalon has a broad median thickening (fig. 9) continuous with that in the floor of the diencephalon. Ventrally this gives rise to the roots of the median oculomotor and trochlear nerve trunks mentioned above.

The interpretation given in the preceding paragraphs of the median ventral cranial nerves in this specimen is supported by the conditions in the nervous system of a dicephalus pig, reported by Bishop ('21), in which there was more extensive duplicity of parts. In that specimen there was complete pairing of the brain rostral to the hind-brain. Correspondingly, nerves I–IV show no fusion, but the more caudally located medial cranial nerves show a greater or less degree of fusion and in the cervical region of the cord a short series of median (conjoined) spinal nerves arise.

In the embryo reported here paired Rathke's pouches (fig. 7), still attached to the oral epithelium by narrow stalks are present. Their points of origin (fig. 6) from the oral epithelium are ventral to the posterior margin of the optic chiasma. The pouches are dorso-ventrally flattened. They still lie against the floor of the diencephalon, but some mesenchyme cells have crept in between them and the diencephalon.

As compared with conditions in normal embryos, or more caudally in the region of the single part of the notochord of this embryo, the differentiation of precartilage around the bifid notochord gives evidence of partial duplication of the centra. The line of fusion of the paired sclerotomes is median as usual, but instead of a central notochord lying in the line of fusion we find the right and left prongs of the notochord located to the sides of the line of fusion towards the center of each lateral half of the centra (fig. 5). Similarly there is evidence of bilateral chondrification around the two prongs of the notochord in the basioccipital region.

COMPARISON AND DISCUSSION

One other similar case is known to me of partial doubling of internal structures in amniote embryos that were apparently normal externally.[2] Terni ('25) describes a 17-mm. chick embryo with bifid notochord, paired hypophyses and infundibula, and a partial doubling of the spinal cord and brain. It is probably correct to assume that Terni's chick and my pig differ only in degree of abnormality, not in kind, from certain other partially or completely dicephalous individuals. Since my embryo was first reported in abstract (George, '42), McCall ('43) has reported a case of duplication of the hypophysis and the floor of the diencephalon in a 10-mm. pig. No external abnormalities are recorded other than a patent anterior neuropore and no mention is made of other neuro-anatomical details or of the notochord. The somewhat scanty illustrations, however, indicate that McCall's spec-

[2] Since this manuscript was completed, my colleague, Prof. C. D. Van Cleave, has called my attention to a paper by Mary Harman (Concerning the origin of the notochord in the chick embryo, 1923, Anat. Rec., vol. 23, pp. 363–369) in which she gives some pertinent data with regard to a 3-day chick embryo, produced through incubation at 106° Fahrenheit, with a notochord doubled at the cephalic end. The bifurcation begins at the "region of the origin of the vitelline veins." In a 3-day chick this would be at about the level of the tenth somites. Two floor plates are present in the neural tube dorsal to the double notochord. The data given with regard to this embryo are in harmony with the interpretation given in the following pages.

imen is essentially like the one reported in this paper. To the left of the reference letter *B* in his figure 1 a structure is shown that compares to the cephalic tip of one prong of the notochord in my series of sections, and in the lower part of his figure 3 (just above the page number) is a structure that appears to be a portion of the other prong of the notochord. Furthermore, in McCall's figures 1–3, between the floor of the diencephalon and the roof of the pharynx, a round structure is observable that corresponds to the median (conjoined) trigeminal nerves of my embryo. Other more completely dicephalous monsters recorded range from individuals with a single head showing some evidence of doubled features to individuals with entirely separate heads, and, as is well known, a graded series connects dicephalous types with identical twins.

That identical twins and conjoined individuals arise through the development of two primitive streaks in the germinal material of a single ovum is generally accepted. According to Gruber ('31) the problem of a dicephalus or a diprosopus involves also the development of two primitive streaks. The writer believes this to be true in some cases only. In many cases the reports of dicephalous monsters do not give data necessary for fundamental comparsions or for conclusions concerning their morphogenesis. In a few cases sufficient data are at hand to make it probable that there are two morphogenetic types of dicephalus. One type is illustrated by the human specimen described in considerable detail by Smith and Boulgakow ('26). This specimen has two separate heads attached to a common trunk. The trunk has two separate or nearly separate vertebral columns. Their origin almost surely began with the differentiation of two parallel and adjacent primitive streaks. Primitive streaks more distant from one another might have produced "identical" separate twins. Another specimen has been reported by Irvine ('43): "A double monster of female sex, possessing two heads and necks attached to a single trunk and with one pair of upper and lower extremities, was delivered at term. A radiograph of the specimen revealed the presence of two vertebral columns with medial rotation of the vertebrae; normal complements of ribs and iliac bones, but with one pubic and one ischial bone on each side; fusion of the medially juxtaposed scapulae."

In the second type of dicephalus there is a variable degree of duplicity of the axial skeleton and other cephalic structures, but more caudally the individual is single and presumably normal. The genesis of the second type of dicephalus is suggested by conditions in the pig embryo reported above, and by the similar conditions in Terni's chick.

The bifid notochord is a conspicuous feature of these fetuses and supplies the key to their genesis. In the development of these embryos it is probably correct to assume that growth proceeded normally until the primitive streak stage was reached. At this stage some abnormal influence acting upon Hensen's node might have caused the outgrowth of a bifid head-process instead of a single median one. The initiation of two growing pionts on Hensen's node instead of the usual single one might have been due to some mechanical injury or more probably resulted from retardation of development at the critical time of head-process formation according to the theories of Stockard ('21) or acceleration of the developmental rate according to Riddle ('23).

Following the outgrowth of two slightly diverging head-processes, it is assumed further that two embryonic axes for the cephalic region of the blastoderm were organized along the two head-processes. Insofar as their propinquity and the amount of material permitted, the two head-processes induced doubling of the neural tube and other structures (as the hypophysis). These modifications of normal processes presumably affected the further sequence of events in the area cephalad to the point of bifurcation of the embryonic axis. Caudad to the point of bifurcation, subsequent to the outgrowth from the primitive knot of two diverging head processes to form the cephalic prongs of the notochord, the single portion of the notochord was differentiated, no doubt, in quite the normal manner (Streeter, '27) from the primitive knot as it receded caudally along the axis of the single primitive streak.

The above explanation of the genesis of this type of monster is in accord not only with the anatomy of the specimen but also with the discoveries of experimental embryologists. It has been known for many years that the dorsal lip of the blastopore in embryos of lower vertebrates has a strong organizing influence. Not only does the whole area of invagination have the power of inducing medullary plate formation, limited areas have more detailed and specific inductor effects (Lehmann, '26; Adelmann, '30; Mangold, '33).

Bautzmann ('28, '33) found that the notochordal rudiment alone might induce medullary plate formation in amphibia and that a displaced strip of notochord would induce a second median plane in the overlying medullary plate. Because of the particularly strong power for induction exercised by the notochord, Bautzmann ('33) considers the notochord to be the physiological axis of the embryo — for its dorsal organs at least. Holtfreter ('34) finds that the substrate influences the morphology of the nervous tissue in addition to inducing its differentiation from ectoderm. An intimate morphological relationship between the notochord and the floor plate of the neural tube has been known for a long time. In a series of observations and well conceived experiments Kingsbury ('22, '24) established that the cephalic limit of the neural floor plate corresponds closely with the cephalic limit of the notochord. In origin also there is an intimate relation between notochord and floor plate. In early stages the floor plate and notochord are closely adherent to one another, and, furthermore, the work of Wetzel ('29) and Pasteels ('37) indicate that they both come from the same source. Both of these investigators find that if Hensen's node be vitally stained so deeply as to stain both its ectodermal and mesodermal components then the entire notochord and the entire length of the floor of the neural tube are stained in the embryo. The implication is that both notochord and floor plate of the neural tube are derived from material of Hensen's node.

It appears that the degree of doubling of the notochord and the angle of divergence of the two portions may vary considerably. In the condition nearest normal there is doubling of the chorda canal alone. Cases of this sort in the guinea pig, occurring before the formation of somites, have been reported by Von Spee (1888) and by Huber ('18). Van Oordt ('21) states that "In Manis we have observed that the chorda canal appears double in many cases." He describes one case and says that in the region of double chorda canal the notochord appears broad, as if incompletely doubled.

Johnston ('32) gives a brief account of conditions in a 11-mm. human embryo in which the notochord was doubled for a short distance at two points, both in the cervical region. In both regions the two chordae lay quite close together, and there were no associated abnormalities of other structures. Another slightly older human embryo (Bergl, '29) has the notochord double at three points through a few sections at each point.

The first of these regions of double notochord occupies twenty-eight sections in the cranial region where the chordae are located dorso-ventrally with reference to each other; the second of these regions and, presumably, the third are in the cervical region and the paired chordae lie lateral to and against each other. There were no associated abnormalities.

In a 14-somite cat embryo Kolmer ('26) reports the notochord double for a short distance beginning at the level of the sixth somites. The most cranial portion is single as is the caudal portion. There are no associated abnormalities in this case either. A slight broadening of the floor of the neural tube, as shown in figure 3 of this paper, is probably the only variation that would result from double notochordal rudiments lying side by side since the organizing capacity of both would be exerted on virtually the same material. At the opposite extreme the angle of divergence of the two head-processes and the resulting two notochords may be so great as to produce two separate or nearly separate heads.

A few cases known to me that should be interpreted as morphologically and embryologically double in the cephalic and cervical region but morphologically and embryologically single in the more caudal regions are a two-headed calf (Smallwood, '21) with two skulls attached by fusion of the temporal bones and with the two brains united from the region of the trapezoid to the posterior margin of the medulla. Smallwood states that "the spinal cord was unmodified." This statement was very likely based on superficial examination only and it seems probable to the writer that detailed examination would have revealed evidence of partial doubling in the upper portion of the cord. There was no doubling of the vertebrae caudally. Dissection revealed that the organs of the body were normal and the blood vessels of the neck showed no marked variation until the head was reached.

A two-headed lamb (Bishop, '08) has brains conjoined only in the region of the medulla just before it continues backward as a single cord. Another two-headed lamb (Reece, '17) was probably similar. In this case supplementary data given concerning the skeleton are important. The more cephalic two thoracic vertebrae and the more caudal five cervical vertebrae appear from the dorsal view to be normal except that they are rather wider than usual. Seen from the ventral view the cervical vertebrae show unusual width. Reece's statements and my own observation of his figures lead me to the conclusion that the doubling very probably began at the level of the second thoracic vertebra.

Thuringer ('19) records some facts concerning the anatomy of a full term dicephalous pig with normal appearing body and neck. The face showed two snouts. There were two median eyes in a common orbit. There were two separate cerebri, two cerebelli and two fused medullae. He states that the cervical vertebrae showed increased transverse diameter and that caudal to the first dorsal (thoracic) vertebra the entire skeleton was normal. Here again the anatomical facts reported permit the assumption that the abnormality began at about the level of the second thoracic vertebra.

Comment might be made here concerning a specimen recently reported by the District of Columbia Department of Health ('43). The specimen was a Collie dog of no unusual external appearance which had been sent to the Department for rabies examination. Examination of the nervous system showed a main brain and a second smaller brain behind the first but attached to the spinal cord. The exact point of attachment was not given. Unfortunately no other significant details were recorded. Assuming that this anomaly arose through outgrowth of two head-processes from one primitive knot the problem is presented of explaining the disparity in size of the two brains. The answer to the problem is to be found possibly in the angle of divergence of the two head-processes from the main axis of the embryo. The conditions for producing a major and a minor brain would be met by assuming that one head-process grew forward approximately in line with the primitive streak and that a second head-process diverged considerably from this angle. The brain that was organized under the influence of the first head-process would have a more favorable position with relation to the primitive vascular pattern than would the brain organized under the influence of the more laterally directed head-process, and since its position gave it the major portion of the carotid blood it would become the main brain.

Both in my pig and in Terni's chick the bifurcation of the notochord begins at the level of the second thoracic vertebra. The data available with regard to Reece's lamb, Thuringer's pig, Smallwood's calf and Bishop's lamb encourage the assumption that the caudal limit of doubling might be at about this same level in those specimens. This suggests the hypothesis that the definitive position of the original primitive knot in embryos generally is at about the level of the second thoracic vertebra and that the portion of the notochord cephalad to this point is derived from the head-process and the more caudal portion derived from the primitive knot as it recedes. This would indicate a greater forward growth of the brain than is ordinarily believed to occur, and the hypothesis seems in opposition, superficially at least, to certain other data. Doubling of axial structures is known to extend to varying levels in some forms. Radiographs of bifid snakes published by Johnson ('00) show considerable variation in the position of the point of bifurcation of the vertebral column. In some cases more than twenty vertebrae are involved. In Bishop's ('21) pig, too, although her report includes no observations with regard to the notochord, my own examination of the specimen studied by her revealed that the notochord was still double at the level of the thirteenth spinal nerves, the caudal limit of the series of sections. A more extensive doubling of the notochord than would be produced by two head-processes might be due to a primitive streak bifid at its cephalic end. A further possible, although it appears to me unlikely, mode of extension of the bifid notochord beyond that which would be produced by paired head-processes is through the organization of two notochords out of the primitive knot as it recedes. Further evidence is required to establish the relation between the primitive knot and definitive structures.

Chorda-hypophysis relationship

The conditions in this embryo with double notochord and in others recorded in the literature draw attention again to the significance of the relationship between the early notochord and the anlage of the hypophysis. The contact between the end of the notochord and the hypophyseal plate led some early embryologists to the conclusion that the notochord aided mechanically in drawing out the plate into a sac (Rathke's pouch). The observations of others (Mihalkovic, 1875; Atwell, '18) caused the abandonment of this view. That a complex of growth factors, especially the expansion of the forebrain and the development of mesoderm in this region, does mechanically influence the morphological transformation of the hypophyseal plate seems clear from the work of Kingsbury and his students (Gilbert, '34; Kingsbury and Romer, '40; Kingsbury, '42, and House, '43). That the formation of the hypophyseal plate itself from stomodeal ectoderm is induced by the notochord is suggested by the presence of an hypophysis at the end of each prong of the bifid notochord in the pig embryo reported in this paper, in the pig described by Bishop (see her figs. 11 and 12), in Terni's chick and in the selachian embryo with bifid notochord described by Wenig ('27) and discussed further by Alexander ('27). This suggestion is strengthened by the findings of Stein ('33) and Rawles ('36), whose data indicate that the presumptive hypophyseal ectoderm is located in the mid-line rostral to the head-process. The observation of Stein that, although it is fairly frequent in grafts from older donors, "hypophysis is chiefly absent from young donors, under 8 somites . . . " may bear some relation to a required minimum duration of action of the inductor.

SUGGESTED CLINICAL SIGNIFICANCE

This case should have some interest for the clinical neurologist in view of the probability that human embryos of this type might develop to maturity and go unrecognized in the general population. The broad forebrain in the embryo suggests the possibility that a full-term individual of this type would have a broad cranium. It is a matter of conjecture as to what extent confusion in mental processes, nervous disturbances or feeblemindedness would result from the possession of a biaxiate brain. A study of the anatomy of the brain, especially the ventral decussations of the brain, in more completely developed specimens of dicephalus with conjoined hindbrains would be of great interest. Such data would provide better anatomical basis for conjecture as to the probable neurological disturbances to be expected in living individuals of this type.

Gesell ('21) has pointed out the high incidence of mental deficiency in hemihypertrophy, which he suggests "may be interpreted as an atypical or imperfect form of twinning . . . " Any consideration of the etiology of hemihypertrophy (especially cephalic) should not overlook the possibility of its having its origin in such a biaxiate brain as is here reported.

SUMMARY

A pig embryo is described which has evidences of internal twinning although no external abnormalities were observed. Caudally from the level of the tenth spinal nerves the notochord is single and other features are normal; rostral to this level the notochord is double, showing diverging prongs. Dorsal to the prongs of the notochord paired floor plates are present in the upper cord and brain. Between the paired floor plates a ridge of nervous tissue is present which represents the medial walls of two incompletely separated brains and cervical spinal cords. From this ridge a series of nerves emerge ventrally in the midline. These are interpreted as being the efferent fibers of conjoined cranial nerves II–VII from the right side of the left component and the left side of the right component of the partially doubled brain. Paired Rathke's pouches and infundibula are present.

A comparison is made with other partially and completely dicephalous individuals, and the genesis of such specimens is discussed in relation to normal morphogenesis and the organizing capacity of notochordal tissue as discovered by experimental embryologists. It is concluded that in the development of an embryo with a single primitive streak, two head-processes grew out from Hensen's node and that these induced the formation of two neural axes in the overlying ectoderm and two hypophyseal plates in the stomodeal ectoderm.

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PLATES

PLATE 1

EXPLANATION OF FIGURES

All figures are photomicrographs of sections, cut 15 μ thick, from a 444-section series. Figures 2–5 are approximately × 50 after reduction; 6–9 approximately × 12.

2 Spinal cord and adjacent tissues in the normal single part of the embryo, twenty-one sections behind the point of bifurcation of the notochord. From section 287.

3 Spinal cord and adjacent tissues at the point of beginning bifurcation of the notochord. Note the somewhat greater size and width of the notochord here compared to figure 2. From section 266.

4 Spinal cord and adjacent structures two sections cephalad to the point of bifurcation of the notochord. As compared with figure 2, observe the somewhat wider floor plate over the prongs of the notochord. From section 264.

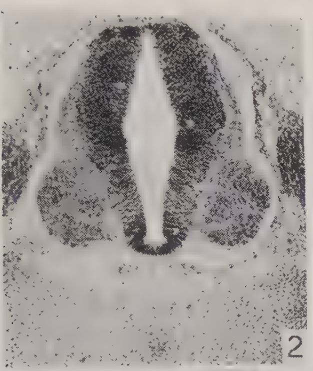
5 Spinal cord and adjacent structures 121 sections further cephalad than figure 4. The two prongs of the notochord are here much farther apart and two floor plates (f. p.) are present with a ridge of neural tissue between them. From section 143.

6 Section no. 149, six sections caudad to figure 5, through the diencephalon at the optic stalk. In the roof of the pharynx beneath the diencephalon observe the points of origin of the paired Rathke's pouches (R. p.).

7 Whole section no. 135. Observe the broad floor of the diencephalon (dien.) with the thickened median ridge of neural tissue, partially dividing the ventricle into right and left portions. Paired Rathke's pouches (R. p.) are located laterally beneath the thin parts of the floor of the third ventricle. Between the floor of the diencephalon and the roof of the pharynx in the mid-line is a large nerve trunk which represents conjoined medial trigeminal nerves (t. n.) of the ''dicephalus.''

8 Section no. 130, five sections cephalad to figure 7, beyond the tip of Rathke's pouch of one side and through the tip of the other side. Adjacent depressions in the floor of the diencephalon are paired infundibular evaginations (inf.). Observe the paired notochords (nch.) cut lengthwise for a distance. The three median nerve trunks to be observed are interpreted as follows: the one nearest the pharynx is fused medial facial nerves (f. n.); the large trunk is fused medial trigeminal nerves (t. n.); the small nerve (n.) between the trigeminal nerve and the floor of the diencephalon arises by three roots as shown in text figure 1.

9 Whole section no. 108, through the midbrain (mesen.), floor of the hindbrain, and spinal cord. A thickened median mass of nervous tissue is shown in the floor of each. Paired floor plates are shown in spinal cord and hindbrain. A fracture in the section has damaged the floor of the midbrain on one side. The medial trochlear nerve (tro. n.) of one side is present in this section.



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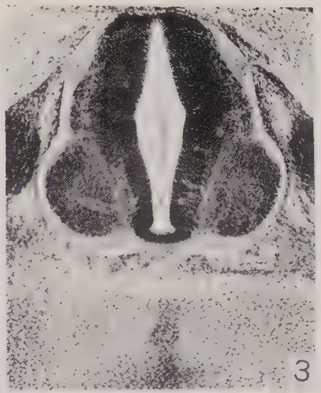

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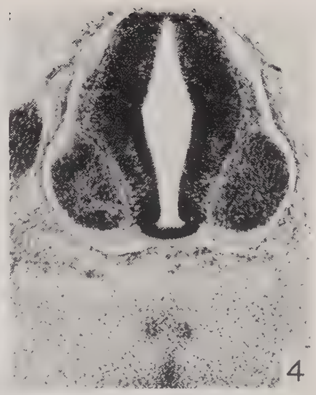

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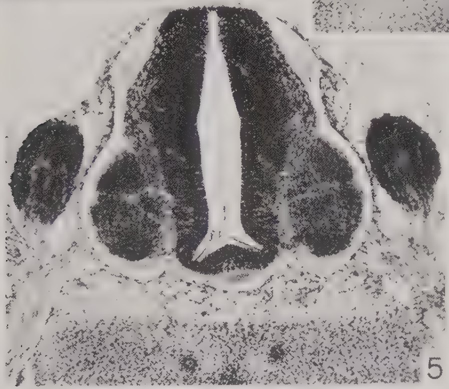

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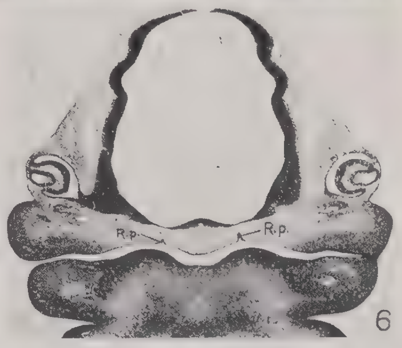

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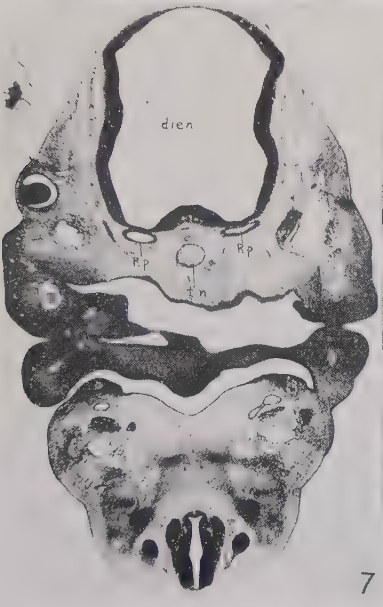

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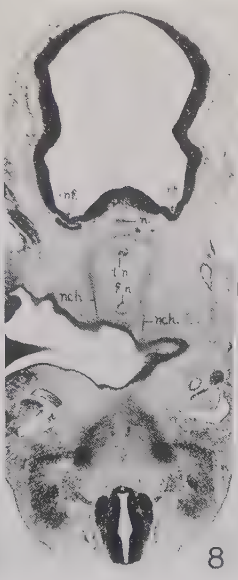
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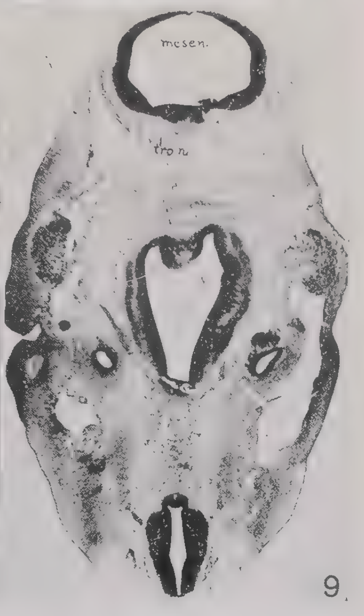

9.

EFFECT OF TESTOSTERONE PROPIONATE ON THERMO-REGULATORY FUNCTION OF RAT SCROTUM[1] [2]

JOHN O. ALMQUIST AND FREDERICK N. ANDREWS[3]
Agricultural Experiment Station, Purdue University, Lafayette, Indiana

The thermo-regulatory function of the mammalian scrotum has been demonstrated by many workers (Moore and Quick, '24; Phillips and McKenzie, '34 and others) and it has long been known that the removal of the testes from the scrotum to the abdominal cavity results in extensive degeneration of the germinal epithelium (Griffiths, 1893; Moore, '22). Phillips and Andrews ('36) found that in the ram, bull and boar, the scrotum acquired its thermo-regulatory function as the testes began the production of spermatozoa and Andrews ('40) reported that the rapid testicular development initiated at about the ninth week in the rat was accompanied by marked responsiveness of the scrotum to temperature change. This function did not develop in rats castrated at 5 weeks of age. Tyrrell, Andrews and Zelle ('42) found that significant decreases in seminal vesicle and scrotal sac weights and in the height of scrotal contraction occurred during the first, second and fourth weeks respectively following castration of the sexually mature rat. Scrotal contraction height and scrotal sac and seminal vesicle weights were highly correlated.

The hormonal regulation of the scrotum has received comparatively little attention. Hamilton ('36) demonstrated marked development of the immature rat scrotum by testosterone acetate. Wells ('37) concluded that the ascent of the testes of the adult ground squirrel to the abdominal cavity during the non-breeding season was not due primarily to scrotal failure and found that testicular regression was paralleled by decreased androgen production and decreased scrotal sac weight. Selye ('43) reported that in immature castrate rats testosterone in itself did not induce full scrotal development nor did it completely prevent scrotal involution in adult castrates unless the scrotum was mechanically distended by an artificial glass testis or the epididymis.

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[1] Journal paper no. 145, Purdue University Agricultural Experiment Station.

[2] A condensation of a thesis submitted to the Graduate Faculty at Purdue University by the senior author in partial fulfillment of the requirements for the degree of Master of Science, January, 1944.

[3] The authors acknowledge the assistance of Dr. M. R. Zelle in the statistical analysis of the data.

However, scrotal size was described in relative terms after visual examination and no scrotal sac weights or contraction heights were recorded.

The purpose of the present investigation was to determine the rôle of testosterone propionate upon the thermo-regulatory function of the scrotum of prepuberally and postpuberally castrated rats.

METHOD

In the first experiment fifty male albino rats, random bred from an original Wistar strain, were castrated at 35 days of age. The testes and epididymides were removed through a medial abdominal incision in order to avoid scrotal injury. Five groups of ten rats each were selected. The height of scrotal contraction was determined at 90 days of age in the first group and the rats immediately autopsied. The second, third and fourth groups were given daily subcutaneous injections of 0.5 mg. of testosterone propionate[4] in sesame oil for 7, 14 and 21 days respectively beginning on the ninetieth day of age. On the day prior to the first injection, the height of scrotal contraction of each rat was measured and on the day following the last injection scrotal contractility was again measured and the rats immediately killed and scrotal sac and seminal vesicle weights obtained. The scrotal contractility of the fifth group (untreated) was recorded on the ninetieth day of age and again on the one hundred and eleventh day just preceding autopsy.

In the second experiment fifty, 90-day-old male rats were divided into five groups of ten rats each. Scrotal contractility was measured in the first group at 90 days and organ weights obtained. After obtaining the initial scrotal contraction at 90 days of age the males in the second, third and fourth groups were castrated and immediately injected with 0.5 mg. of testosterone propionate daily for 7, 14 and 21 days respectively. The day following the last injection scrotal contractility was again measured and scrotal sac and seminal vesicle weights obtained. Untreated rats of the fifth group were castrated at 90 days of age immediately after obtaining a scrotal contraction record. On the one hundred and eleventh day the final scrotal contraction was measured and scrotal sac and seminal vesicle weights secured.

Scrotal contractility was measured by passing a thread through the scrotal skin midway between the scrotal tip and the body. The thread was attached to a recording lever and the scrotal contraction magnified and recorded upon a manually operated kymograph drum. The rats were anesthetized with nembutal and ether, fastened to a heavy metal screen and submerged, with the exception of the head, in a water bath. The initial scrotal contraction was obtained by maintaining the temperature of the water at 38–40°C. for 10 minutes. At the end of this time the drum was turned and a base line recorded. The temperature was then lowered to 20°C. and held at that temperature for 10 minutes. The drum was then turned, recording the height of contraction. The temperature was then raised to 38–40°C., held for 10 minutes and a second base line drawn. The height of contraction was expressed in millimeters by averaging the distances from the first and second base lines to the contraction line.

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[4] Generous supplies of testosterone propionate were provided through the courtesy of Dr. Erwin Schwenk of the Schering Corporation, Bloomfield, New Jersey.

Seminal vesicle and scrotal sac weights were obtained by removing the organs, blotting with filter paper to remove excess fluid or secretions and weighing on an analytical balance. The data were treated statistically by the methods of analysis of variance and correlation outlined by Snedecor ('40).

RESULTS

Effect of testosterone propionate on prepuberally castrated rats

The mean values for the measurements made appear in table 1 and a summary of the analyses of variance is presented in table 2. The data indicate that the injection of testosterone propionate into prepuberally castrated rats produced highly significant increases in the height of scrotal contraction. The analysis of variance of final contraction height indicates highly significant differences between the mean heights of contraction of both the 90- and 111-day castrate controls and the androgen injected groups. An analysis of the difference in contraction before and after hormone treatment showed highly significant differences between the mean of the 111-day castrate controls and

TABLE 1

Summary of means for rats castrated at 35 days of age.

TREATMENT	INIT. SCRO. CONTR.	FINAL SCRO. CONTR.	CONTR. DIFF.	SCROTAL SAC WEIGHT	SEMINAL VESICLE WEIGHT
	mm.	*mm.*	*mm.*	*gm.*	*gm.*
90 day control	7.1			0.0914	0.0078
Inj. 7 days	7.1	18.5	+ 11.4	0.1752	0.0712
Inj. 14 days	10.6	24.4	+ 13.8	0.2426	0.2198
Inj. 21 days	11.5	31.6	+ 20.1	0.2714	0.3072
111 day control	10.9	9.7	— 1.2	0.1172	0.0088

each of the injected groups and that the difference between the rats injected for 21 days and the other hormone treated groups was highly significant. It is observed in table 1 that the initial height of scrotal contraction varied between groups. Significant differences were observed between the following groups: 90- and 111-day controls, 90-day controls and 14-day injected, 111-day controls and 7-day injected, and the 7- and 14-day injected. These initial differences do not affect the conclusions which have been drawn, but if there had been less variation in the initial measurements it is probable that even more striking results would have been observed.

TABLE 2

Analyses of variance for initial contraction height, final contraction height, contraction difference, scrotal sac and seminal vesicle weights of rats castrated at 35 days of age.

	SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Initial contraction height	Total	49	718	
	Between groups	4	186	46.500 [1]
	Within groups (error)	45	532	11.822
Final contraction height	Total	49	4781.6	
	Between groups	4	4135.3	1033.830 [1]
	Within groups (error)	45	646.3	14.362
Contraction difference	Total	39	3023	
	Between groups	3	2396	798.667 [1]
	Within groups (error)	36	627	17.417
Scrotal sac weight	Total	49	.31366	
	Between groups	4	.24089	.060222 [1]
	Within groups (error)	45	.07278	.001617
Seminal vesicle weight	Total	49	.74394	
	Between groups	4	.72296	.180740 [1]
	Within groups (error)	45	.02099	.000466

[1] Highly significant.

An analysis of scrotal sac and seminal vesicle weights indicates that testosterone propionate produces significantly heavier scrotal sacs and seminal vesicles in rats castrated at 35 days of age and injected beginning on the ninetieth day of age. There was no significant difference in scrotal sac weight of the 90- and 111-day castrate controls. The weights of the scrotal sacs of the rats treated for 14 and 21 days were highly significantly greater than in the 7-day group. There appeared to be a direct relationship between seminal vesicle weight and injection period. Treatment for 7 days produced seminal vesicles 800% heavier than the 90-day controls and injection for 14 and 21 days resulted in increases of 2700 and 3800% respectively.

There was a highly significant correlation of 0.833 between final contraction height and scrotal sac weight. Correlations of 0.896 and 0.825 between final contraction height and seminal vesicle weight and scrotal sac and seminal vesicle weights respectively were obtained.

It appears, therefore, that the injection of testosterone propionate into prepuberally castrated rats results in the development of the thermo-regulatory function of the scrotum and the stimulation of growth of the scrotal sacs and seminal vesicles.

Effect of testosterone propionate on postpuberally castrated rats

The objectives of this experiment were to determine if the thermo-regulatory function of the scrotum, and scrotal sac and seminal vesicle weights could be maintained in rats castrated after sexual maturity (90 days). The mean values for the measurements made appear in table 3 and a summary of the analyses of variance is presented in table 4.

TABLE 3

Summary of means for rats castrated at 90 days of age.

TREATMENT	INIT. SCRO. CONTR.	FINAL SCRO. CONTR.	CONTR. DIFF.	SCROTAL SAC WEIGHT	SEMINAL VESICLE WEIGHT
	mm.	*mm.*	*mm.*	*gm.*	*gm.*
90 day control	34.8			0.545	0.202
Inj. 7 days	38.4	55.3	+ 16.9	0.557	0.386
Inj. 14 days	34.9	50.0	+ 15.1	0.510	0.452
Inj. 21 days	34.2	49.1	+ 14.9	0.538	0.425
111 day control	42.8	24.7	— 18.1	0.381	0.090

An analysis of final contraction height indicates that the injection of testosterone propionate maintains the thermo-regulatory function of the adult castrate rat scrotum. There were no significant differences in the means of the groups injected for 7, 14 and 21 days, but the contraction height of each of the injected groups was highly significantly greater than for the uninjected controls. As expected, there was a highly significant decrease in contractility of the rats which had been castrated but untreated for 3 weeks. The injection of testosterone not only maintained scrotal contractility but significanly increased the final height of contraction by approximately 45% when comparisons were made with the 90-day controls. An analysis of contraction differences showed that the mean difference of the 111-day castrate controls varied significantly from each of the injected group. As in the first experiment, there were significant differences in the mean initial heights of contraction between groups (table 3). The mean initial contraction of the 111-day castrate control group was significantly greater than the mean initial contraction of the 90-day control and the 14- and 21-day injected groups. This indicates that one cannot assume that an experiment is adequately controlled if animals of similar breeding are selected at random and that a suitable analysis of the data is necessary if sound conclusions are to be drawn.

TABLE 4

Analyses of variance for initial contraction height, final contraction height, contraction difference, scrotal sac and seminal vesicle weights of 90-day-old castrate rats.

	SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Initial contraction height	Total	49	2279	
	Between groups	4	527	131.75 [1]
	Within groups (error)	45	1752	38.93
Final contraction height	Total	49	9033	
	Between groups	4	6394	1598.50 [2]
	Within groups (error)	45	2639	58.64
Contraction difference	Total	39	11380	
	Between groups	3	8558	2852.67 [2]
	Within groups (error)	36	2822	78.39
Scrotal sac weight	Total	49	.515	
	Between groups	4	.208	.0520 [2]
	Within groups (error)	45	.307	.0068
Seminal vesicle weight	Total	49	1.142	
	Between groups	4	.994	.2485 [2]
	Within groups (error)	45	.148	.0033

[1] Significant.

[2] Highly significant.

There was a highly significant decrease in scrotal sac weight in rats which had been castrated for 3 weeks (111-day castrate controls) and no differences in scrotal sac weight between the various injected groups. It is concluded, therefore, that the injection of testosterone propionate in postpuberally castrate rats maintains scrotal sac weight. The seminal vesicles of the 111-day castrate controls were highly significantly smaller than those of any other group. The injection of androgen for periods of 1 to 3 weeks approximately doubled the weights of the seminal vesicles as compared with the normal 90-day controls.

Although significant correlations between scrotal contraction, scrotal sac and seminal vesicle weights were obtained they were not as striking as in the prepuberally castrated rats. A significant correlation of 0.332 ($P<0.05$) was obtained between final contraction height and scrotal sac weight. Highly significant correlations of 0.678 and 0.589 ($P<0.01$) were found between final contraction height and seminal vesicle weight and between scrotal sac and seminal vesicle weights respectively.

It appears that in postpuberally castrated rats testosterone propionate results in slight increases in scrotal contractility and maintains rather than increases, the weights of the scrotal sacs.

DISCUSSION

Evidence accumulated during the past decade indicates but does not clearly prove that the development and maintenance of the thermoregulatory function of the scrotum is dependent upon the testicular hormone. It has been previously demonstrated that the maintenance of the seminal vesicles is dependent upon a source of androgens (Moore, '39 and others), that injection of testosterone acetate produces marked enlargement of the immature rat scrotum (Hamilton, '36), that lowered male hormone production results in decreased scrotal sac weight in the ground squirrel (Wells, '37), that prepuberal castration prevents normal development of scrotal contractility in the rat (Andrews, '40) and that castration of sexually mature rats causes a decline in scrotal contractility and weights of the scrotal sacs and seminal vesicles (Tyrrell, Andrews and Zellé, '42).

The data presented in this experiment indicate that the injection of testosterone propionate into adult rats, deprived of their natural source of testis hormone by prepuberal castration, caused highly significant increases in scrotal contractility and scrotal sac and seminal vesicle weights. Injections of the hormone into adult rats castrated after the attainment of full sexual maturity adequately maintained scrotal sac weight and significantly increased both scrotal contractility and seminal vesicle weight. These data clearly show that normal scrotal function can be developed and maintained by supplying testosterone propionate to rats from which the natural source of androgens had been removed by gonadectomy.

In a recent paper Selye ('43) reported that testosterone alone would not induce full scrotal development in immature rats nor would it completely prevent scrotal involution in gonadectomized adults unless the scrotum was mechanically distended. He concluded that both hormonal and mechanical factors have a rôle in scrotal development. The conclusions, however, were based purely on observation of the relative size of the scrotum and no quantitative measurements such as scrotal sac weight or scrotal contractility were made. In our experience it is difficult, if not impossible, to make comparative studies of the anatomy and physiology of the scrotum without using objective measurements.

In the present experiments castration was performed through a medial abdominal incision in order that the scrotal structure would not be disturbed and the epididymis was routinely removed with the testis. Observations at the time of autopsy did not reveal any scrotal distention by remnants of the epididymis. The data indicate, therefore, that the results obtained were due to the presence or absence of the testicular hormone and not to mechanical stimulation of the scrotal sacs.

SUMMARY

1. Significant increases in height of scrotal contraction, and weights of the scrotal sacs and seminal vesicles were obtained following the injection of testosterone propionate into rats castrated at 35 days of age and injected for periods of 7 to 21 days beginning on the ninetieth day of age.

2. The injection of testosterone propionate into sexually mature rats following castration on the ninetieth day of age adequately maintained scrotal sac weight and significantly increased seminal vesicle weight and the contractility of the scrotum.

3. The results of this study provide additional evidence that the thermo-regulatory functions of the rat scrotum is dependent upon the testicular hormone.

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ACTIVITY OF THE GERMINAL EPITHELIUM IN THE OVARY OF A PREGNANT HARVEST MOUSE[1]

KENNETH L. DUKE
Department of Anatomy, Duke University School of Medicine, Durham, North Carolina

ONE PLATE (SIX FIGURES)

INTRODUCTION

Despite the numerous publications dealing with the production of germ cells in female mammals, evidence for or against the formation of new germ cells in the sexually mature adult is still desirable. It is with an interest in seeing such evidence accumulate that these brief observations are reported.

MATERIAL

This mouse is a specimen of Reithrodontomys mexicanus cherrii and was trapped in Panama, in April of 1937. The uterus contained three early embryos, all of which were in one uterine horn. The three corpora lutea were all in one ovary making it much larger than its mate.

OBSERVATIONS

On studying the sections of the non-ovulating ovary the activity of the germinal epithelium appeared extraordinary for a sexually mature animal. This paper will deal with a description of this activity.

The inactive germinal epithelium consists of a single layer of flattened cells. Cell boundaries are not visible since the ratio of cytoplasm to nucleus is so reduced that the oval nuclei bulge out at the free surface (fig. 1).

Areas of activity in the germinal layer modify this conventional structure. In some places areas of stratified epithelium are present, in which can be seen enlarged cells having spherical nuclei and a border of rather clear cytoplasm limited by visible cell membranes (fig. 2). Similar cells also appear to be "pushed" into the cortex (fig. 4). Figure 3 shows a cell in the germinal epithelium identical in size and appearance with an oocyte. Another type of activity is shown in figure

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[1] This specimen was given to me by Dr. Robert K. Enders of the Department of Zoology, Swarthmore College. For his kindness and interest I wish to express sincere appreciation.

5; an invagination into the cortex of cells, some of which are larger and more spherical than others. Other cortical cellular cords, proliferated form the germinal epithelium, contain cells of various sizes, including oocytes (fig. 6).

These areas of activity are not restricted to the hilar region but are found readily on practically any portion of the ovarian surface. The ovary containing the corpora lutea showed activity of the same sort. Areas of activity were usually found only in surface regions not overlying corpora lutea. However, if a corpus luteum did not extend too close to the ovarian surface, areas containing germinal epithelium proliferations were found extending into the cortex above it.

DISCUSSION

The significance of this specimen is that it furnishes an example of a sexually mature mammal which is exhibiting germ cell production in a manner similar to, if on a more reduced scale, than that seen in the gonads of other species before and shortly after birth. The conventional prophase stages of meiosis are not encountered, as they are in the formation of the first germ cells. Much the same, however, is the apparent development of oocytes from epithelial cells of the germinal epithelium by means of a growth process, as evidenced by the presence of transitional stages.

Evidence for ovogenesis in sexually mature mammals, similar to that described here, has been reported by Everett ('42) in the opossum, Gérard ('32) in the lemur, Guthrie and Jeffers ('38) in the bat, Hargitt ('30 b) in the rat, and Pliske ('38) in the ground squirrel. Of these authors only Gérard described meiotic prophase stages, and his figures represent germ cell proliferation of enormous proportions — strikingly similar to that seen in embryos or early postnatal mammalian ovaries. Whether or not the lemur differs from other mammalian forms in this respect will have to await further observations. Most workers who have followed the germ cell history in a rather complete developmental series of mammalian ovaries (Butcher, '27 and Hargitt, '30 a, in the rat, Kingery, '17, in the mouse and Duke, '41, in the rabbit) state that most, if not all, of the early germ cells (those exhibiting meiotic prophase stages) degenerate and that cells from later proliferations of the germinal epithelium give rise to the definitive germ cells. The harvest mouse would appear to fall in the same category as the mouse, rat, and rabbit in this respect, since no evidence of meiotic prophase stages was observed in the enlarged spherical cells apparently produced by the germinal epithelium.

The activity of the germinal epithelium of this pregnant harvest mouse suggests the transformation of the flattened, inactive epithelium (fig. 1) into active areas of cuboidal cells (figs. 2, 4, 5, and 6). Some of these cells appear to enlarge in the germinal epithelial layer (fig. 2) and take either of two courses: (1) complete their development into oocytes in the germinal epithelium (fig. 3), or (2) to be ''pushed'' into the cortex (fig. 4), there to give rise to oocytes. Cords of cells are proliferated into the cortex (fig. 5) where the enlarged spherical cells develop into oocytes (fig. 6).

Additional studies covering greater numbers of individuals in several mammalian groups, appear to be needed before it can be determined whether or not new germ cells are formed in sexually mature mammals.

SUMMARY

The activity of the germinal epithelium in the ovary of a pregnant harvest mouse suggests the formation of new germ cells. These cells appear to be formed in different ways: (1) enlarged spherical cells in the germinal epithelium complete their development into oocytes in that layer; (2) single enlarged spherical cells may be ''pushed'' into the cortex, there to give rise to germ cells; and (3) cords of cells proliferated by the germinal epithelium into the cortex contain cells which develop into oocytes.

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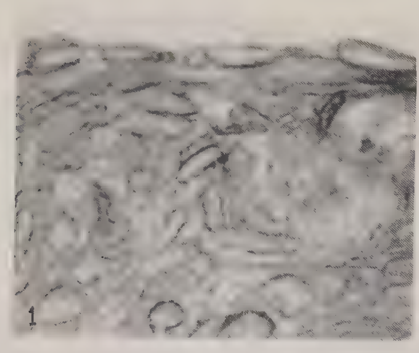

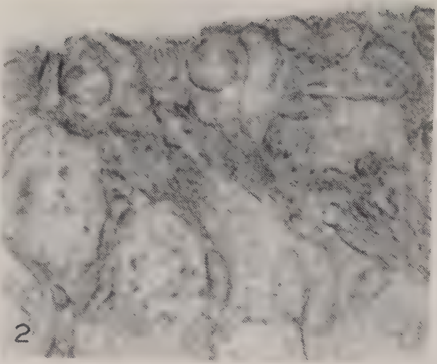

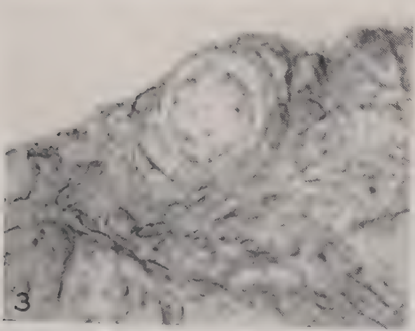

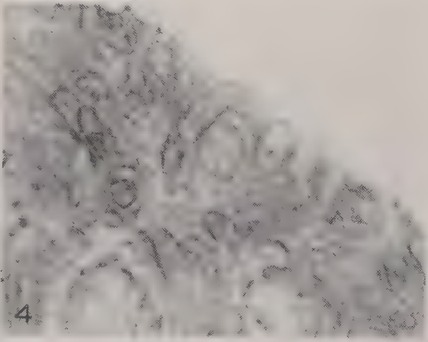

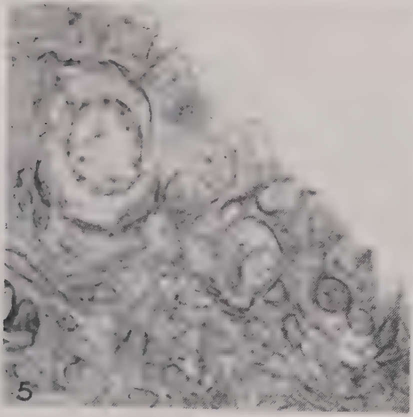

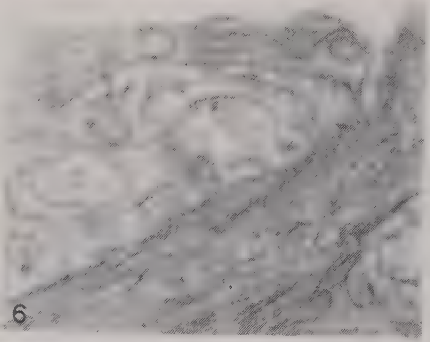

1 Inactive germinal epithelium.

2 Two enlarged spherical cells in an active area of the germinal epithelium.

3 An oocyte in the germinal epithelium.

4 An enlarged spherical cell in the germinal epithelium being "pushed" into the cortex.

5 An invagination of the germinal epithelium into the cortex. The cells vary in size and shape.

6 The upper left portion of the figure illustrates the shape of the active germinal epithelium. To the right can be seen the indipping of the germinal epithelium giving rise to the cord of cells, extending to the left, into the cortex. This cord contains three oocytes.

EARLY EFFECTS OF INANITION ON THE STRUCTURE OF MOTOR END PLATES[1]

EBEN J. CAREY

Department of Anatomy, Marquette University School of Medicine, Milwaukee, Wisconsin

THREE PLATES (SEVEN FIGURES)

There is inadequate knowledge of the effects of acute inanition upon the structure of the neuromuscular apparatus. While changes in the gross weights of the nervous and muscular systems have been observed in both growing and adult rats by Hatai ('04), Donaldson ('08), Lowrey ('13), Jackson ('15), and others, and both Morgulis ('23) and Jackson ('25) have compiled excellent, comprehensive reviews on the effects of inanition upon the different organs in various animals, there is much to be learned about histological changes in inanition.

As to nerve endings, the early studies of Sokoloff (1876) contain the claim that the motor nerve endings in fasting summer frogs are enlarged. Woollard ('27) has made the only study found in the literature on the effect of inanition upon the motor end plates in a warm-blooded animal, namely, the albino rat. Woollard ('27), however, gives no functional significance to the morphologic changes in the motor nerve plates following acute starvation. Carlson ('16) makes the very significant observation that a state of hunger in protozoa is a state of increased excitability and that expressions of states of hunger may be manifested by "augmentation of ameboid movements, increased rate of contraction of pseudopodia acting as feeders." These observations bear added significance in reference to the motor nerve plates since the demonstration by Carey ('41–'42) that the pleomorphism of these nerve findings is a manifestation of the ameboid changes of the ultimate branches of the axis cylinder that lie below the sarcolemma and within the muscle fiber.

Speidel ('42) studied the growth adjustments of cutaneous terminal arborizations and the changes induced by electric shock, starvation, chloretone anesthesia, wound infliction, insulin, and heat. He concluded that the patterns of cutaneous nerve endings are not necessarily fixed

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and stable. The same conclusions were made by Carey ('41) in reference to the pleomorphism of the motor nerve plates in intercostal muscle under various conditions of physiological and pathological function.

Jackson ('15 b) and others have demonstrated that the musculature loses weight seven to ten times faster than the nervous system. This loss relatively increases the mass of the morphologically resistant nervous system over that of the less stable starved muscles. Jackson ('15 b) makes the significant observation that "a very slight gain occurred of the spinal cord in absolute weight during the period of acute inanition." However, he did not study the morphologic changes in the motor nerve plates nor the functional fibrillation of muscle that occurs in some muscle fibers in acute inanition of the albino rat ('15 a, b; '25).

The purpose of this paper, therefore, is to record the easily verifiable morphologic changes that occur in the motor end plates following acute inanition in the ablino rat. Such an experimental morphologic study eventually may throw light upon the nature of the normal neurotrophic influence, transmitted through the neuromuscular apparatus, no skeletal muscle.

MATERIALS AND METHODS

Eighty well-nourished adult albino rats (Mus norvegicus) were fed oats, corn, meats, and vegetables for 3 weeks. Three days before starvation began, the animals were placed on a diet of bread and milk. When the starvation experiments began, all food was stopped but the animals were allowed plenty of water. The initial average weights ran from 180 to 355 gm. During the period of starvation four animals were killed by chloroform every 24 hours up to 15 days. Ten animals died between 12 and 15 days after acute starvation. Between 1 and 15 days the loss in weight varied in the individual rats and was greater during the first days than during the middle or last third of the starvation period. Ten animals were used as controls.

Subsequently, the muscle tissue was stained by the modified gold chloride method previously described by Carey ('41 a, b) — the best histologic procedure we found for displaying the morphologic continuity of axons, motor end plates, and muscle fibers. Although the different muscles of the rat were excised and subjected to the gold chloride technique, teased, mounted and photographed, only the findings supported by the evidence observed in the intercostal muscle fibers will be reported in this paper because of the ease of comparison with facts previously published. A considerable number of histological methods was used, namely, the Marchi method for the medullary sheath, the Bielschowsky silver method, and the intravitam staining with methylene blue. Many of the gold chloride preparations were counterstained with hematoxylin or with toluidin blue and safranin. In the silver method the preparations of the muscle and nerve endings must be studied in serial sections. Finer microscopic details of cytology are observed in the silver preparations but the continuity and mode of ending of the axon are not as clearly demonstrable as in the teased preparations subjected to either the gold chloride or methylene blue techniques.

While the Marchi method was used to demonstrate degenerative changes in the myelin sheath, emphasis in this paper will be laid upon the findings in the axis cylinders of medullated motor nerves, following inanition, as revealed by the gold chloride method, for these findings are considered primary. Similarly, Parker and Paine ('34) have claimed that in the degeneration of a medullated nerve fiber the changes in the myelin sheath were secondary to those in the axis cylinder, especially in the neurofibrillar system. However, others, like Gerard ('32), stress the interdependency of the myelin sheath and the axis cylinder. The latter author states that acetylcholine is closely related to phospholipin, an end product of the breakdown of myelin and, must therefore, be considered as providing evidence for the possible participation of myelin in the active metabolism of nerve.

THE CHANGING MORPHOLOGY OF THE MYONEURAL JUNCTION

I. Normal appearance of fibers and end plates

Consideration of the various forms assumed by the intercostal muscle fibers and end plates, under relatively normal conditions and under those of increased functional activity as induced by CO_2 (figs. 1 and 2), are necessarily preliminary to any evaluation of the morphologic changes produced by acute inanition. The normal motor end plates of the albino rat (fig. 1) vary in length from 24 to 55 microns as measured in the long axis of the intercostal muscle fiber (c.f. Carey, '41 a, b; Carey, Zeit, and Massopust, '42). The associated axons vary in width from 1 to 10 microns, respectively, in the regions of greatest constriction and dilatation. In many places the muscle fibers show evidence of fractional contraction. This is manifested by the occurrence both of darkly stained relaxed muscle fibers (characterized by coarse, widely spaced cross striations and a retracted nerve plate surrounded by a dark granular halo — the sole plate of Kühne) and of lightly stained contracted muscle fibers (characterized by fine closely-spaced striae and an expanded motor end plate around which there is a diminished quantity of the granular sole plate of Kühne). In some of the contracted muscle fibers the dark band is narrower and the light space broader than the corresponding structures in the relaxed muscle fiber.

When corresponding intercostal muscles are subjected to carbon dioxide stimulation, the majority of muscle fibers reveal increased activity, respirations having been accelerated from 60 (fig. 1) to 200 per minute (fig. 2). Structurally the change is indicated by (1) a widening of the muscle fibers, (2) a narrowing of the cross striations so that they appear finer, and (3) a great expansion of the motor end plates. These last exhibit a greater number of terminal arborizations and a greater surface area than the relatively inactive nerve plates in the relaxed muscle fibers (fig. 1). Stimulation of the nerve plates appears to favor the new formation of axonic processes by protoplasmic streaming and ameboid motion. The end plates stimulated by carbon dioxide vary in length from 24 to 100 microns measured along the long axis of the muscle fiber. Seventy-five per cent of these fibers contain end plates that measure 60 to 100 microns in length.

The granular sole plate of Kühne disappears from the greatly expanded end plate stimulated by carbon dioxide, as is shown, e. g., in the last muscle fiber to the right of figure 2. There are thirty double cross striations related to this greatly expanded nerve plate. In contrast there are only ten to fifteen single coarse and broad dark cross striations related to the retracted nerve plates in the relaxed muscle fibers of the relatively normal intercostal muscle (fig. 1). The granular sole plate of Kühne, therefore, appears to be highly inconstant. Apparently this granular sole plate increases in size during the period of muscular rest and relaxation and is dissipated under conditions of augmented and accelerated muscular contraction. Is this granular sole plate related to acetylcholine? In this granular sole plate morphological evidence of cholinesterase? The morphological changes do not answer these two questions at the present time, but they do support the chemical theory of neuromuscular transmission and also the theory that there is a transfer of liquid neurotrophic substance from nerve to muscle.

II. Effects of inanition

Five to 7 days after acute starvation began, two definite structural changes had occurred at the motor nerve plates: (1) coral-like retraction of the hypolemmal ramifications of the terminal branches of the axis cylinder and loss of the granular sole plate of Kühne, and (2) enormous distension of the epilemmal branches of the axis cylinder forming retention cysts (figs. 3 and 4). The chemical content of the axis cylinders varies intensely with gold chloride (figs. 3, 4, and 7). This intense staining reaction of the distended axis cylinders supports the claim that there is a back-pressure accumulation of the liquid axonic substance rather than distension by some pathologic edematous process through absorption of fluid from without the nerve fiber.

The largest globular and allantoid-shaped distensions, or retention cysts, of the axis cylinder vary from 15 to 40 microns in diameter (figs. 3 and 4). The passive vascular hyperemia accompanying inanition results in increased visibility of a vascular ring around some of the end plates (fig. 4). Wilkinson ('29–'30) designates this vascular loop as the "confluens capillorum." It is a highly inconstant vascular ring found around about 10% of the end plates.

The muscle fibers that contain the uniformly fine dark cross striations separated by narrow light spaces (fig. 4) stain intensely red with neutral red. This indicates a state of increased acidity due to the accumulation of metabolites, probably sarcolactic and other organic acids. The change in the capillary chemistry and reaction of the striped muscle fiber is accompanied by a corresponding change in the internal structure of the cross striations. In some places the close approximation of the exceedingly fine dark cross striations (0.2 to 1 micron in width measured in the long axis of the muscle fiber) gives a homogeneous appearance to the structure of the muscle fiber when observed under the low power of the microscope. In other places the condensation of the muscle protoplasm is increased to the point of complete homogeneity, determined by the oil immersion lens, where no transverse periodic organization is visible within the muscle fiber.

During the first 48 hours 70% of the intercostal muscle fibers contain end plates 55 to 90 microns measured in the long axis of the muscle fiber (fig. 6). This is in contrast to those in normal muscle fibers (fig. 5) which have end plates that measured 24 to 55 microns. The increased size of the motor end plates during the first 48 to 96 hours of starvation is correlated with the increased excitability, augmented respiratory rate, and restless activity of the albino rats. The normal respiratory rate varies from 25 to 60 per minute. During the first 5 days of acute starvation it varies from 40 to 100 per minute, and from the seventh to the fifteenth day it drops to the low rate of from 15 to 30 per minute. The dark, relaxed, and lightly stained contracted fibers of the normal intercostal muscle (fig. 5) are clearly contrasted with the uniform types of muscle fibers at 48 hours (fig. 6) and 7 days after acute inanition began (fig. 7). There is a progressive increase of longitudinal striation of the muscle fibers and in the visibility of the longitudinally oriented nuclei from the second (fig. 6) to the seventh day (fig. 7) of acute starvation.

Irregular groups of closely approximated cross striations alternating with those more widely spaced are found throughout some muscle fibers and only in a part of the length of other fibers (fig. 7). These periodic and unperiodic patches of cross striations appear coincident in time with the manifestation of the slow, ceaseless, random, and incoordinated contractions observed in the whole and parts of the single muscle fibers in the intact living muscle from the seventh to the twelfth days of acute starvation. This irregular and abnormal fibrillation of certain muscle fibers is, likewise, coincidental with their progressive denervation by inanition. This inanition denervation at the myoneural junction is highly variable in the fibers of a single muscle and in the different muscles of the rat.

The deep staining with gold chloride of the distended axons (figs. 3, 4 and 7) is contrasted with that of the normal (fig. 5) and of the axons 48 hours after acute starvation (fig. 6). This striking increased capacity to take the gold chloride by the contents of the dilated axons which form retention cysts (fig. 7) 7 days after acute inanition began, supports the proposal that the accumulation was not due to pathologic oedema but to a back-pressure produced by damming up the normal axonic liquid undelivered to the atrophic muscle fibers which have a decreased functional demand for this axonic nerve substance.

The effects of acute inanition proceed at different rates in the muscle fibers and end plates of the same starved intercostal muscle. By the twelfth day there is complete retraction resulting in the uprooting of the nerve endings from within many muscle fibers. The epilemmal axons, in many places, terminate in spherical knobs, cones, or Indian clubs. They are found external to and between the atrophied and acutely degenerated muscle fibers. About 90% of these distended epilemmal terminals have retracted processes that penetrate the sarcolemma of the muscle fibers. The others are in contact with but external to the sarcolemma. Acute cachexia, therefore, causes an epilemmal position of about 10% of the motor nerve endings by progressive ameboid retraction of the processes that originally occupied a hypolemmal position. This results in a morphologic inanition-denervation at the myoneural junction. The state of nutrition, therefore, may determine either the hypolemmal or the epilemmal position of the motor end plates in intercostal muscle of the albino rat. This is a striking correlation of the intimate dependency of the morphology of the nerve plate upon the underlying biochemistry and state of nutrition. These facts are necessary in the evaluation of the morphology of apparently normal motor end plates.

The myelin sheath undergoes progressive degeneration in a central direction from the myoneural junction demonstrated by the Marchi's method. The changes of distention of the epilemmal axon and retraction of the end plate precede those associated with dissolution and degeneration of the myelin. In many places the black staining granules of the myelin sheath appear to contribute substance to the greatly distended axis cylinder. There is only slight chromatolysis of the Nissl granules in the enlarged ventral motor horn cells of the spinal cord in the 5- to 7-day starved rat. This beginning dissolution of Nissl substance is comparable to that found after fatigue in rats running in a treadmill. The chromatolysis is more definite, however, in beriberi than in inanition. The nuclei of the ventral horn cells are either pycnotic or in various degrees of granular dissolution in the late stages (10 to 15 days) of acute inanition. The complete study of the early and late changes in the nerve cells following acute inanition is reserved for a subsequent communication.

DISCUSSION

Acute inanition produces structural variations of the neuromuscular apparatus. There appears to be a correlation between the chemical and structural changes in the striped muscle fiber, (Carey, '41 a and Carey, Zeit, and Massopust, '42). This concept of the changeable chemistry of muscle is supported by the recent work on the acidity and alkalinity of nerves by Gesell ('42), not to mention many others. When nerves become too acid, Gesell discovered that they discharge excessive quantities of the chemical, acetylcholine. This activates the muscle in response to the nerve impulse. Too little oxygen and too much carbon dioxide causes acidity and the reverse causes alkalinity. Increased alkalinity facilitates the destruction of the nerve chemical, acetylcholine. The slight shifts from just the proper balance to excessive acidity or alkalinity of the nerves may influence the activity of the muscles in health and in disease. The variations in the morphology of the neuromuscular apparatus under the influence of CO_2 and electricity (Carey, '41 b and '42) may, therefore, be structural expressions of the various changes in the underlying chemical reactions. Future investigation may reveal a closer interrelationship between the variable biochemistry and the changeable morphology of the myoneural junction than is appreciated at the present time.

SUMMARY

The effects of acute inanition on the neuromuscular apparatus are the following:

1. Within the first 48 hours there is an expansion of 70% of the motor end plates within the intercostal muscle fibers correlated with acceleration in rate of respiration and increased excitability of the albino rat.

2. The retracted motor end plate in the normally relaxed muscle fiber is surrounded by the granular sole plate of Kühne. The greatly expanded nerve plate in the contracted muscle fiber stimulated by CO_2 shows a progressive diminution of the granular sole plate of Kühne to the point of complete depletion. It is proposed that the structural variations of the motor end plate are due to normal and abnormal ameboid motion.

3. The muscle fiber types due to normal fractional contraction in the intercostal muscle are lost either by abnormal CO_2 stimulation or by changes in the chemical substances of muscle by acute inanition.

4. From 5 to 12 days after the beginning of starvation there are: (1) progressive retraction of the hypolemmal ramifications of the axis cylinders from within many of the intercostal muscle fibers, and (2) an enormous acute dilatation of the epilemmal branches of the axis cylinder. The sarcolemma appears to be the location of the dam related to these changes. Acute inanition appears to produce a block to the normal transmission of the axonic nerve substances to the muscle fiber.

I wish to express sincere gratitude to Mr. Leo Massopust for aid with the photomicrographs; to G. Kasten Tallmadge for reading the manuscript and to John Schmitz, James Keyes, and Eugene Haushalter for technical aid in teasing the innervation of muscle fibers.

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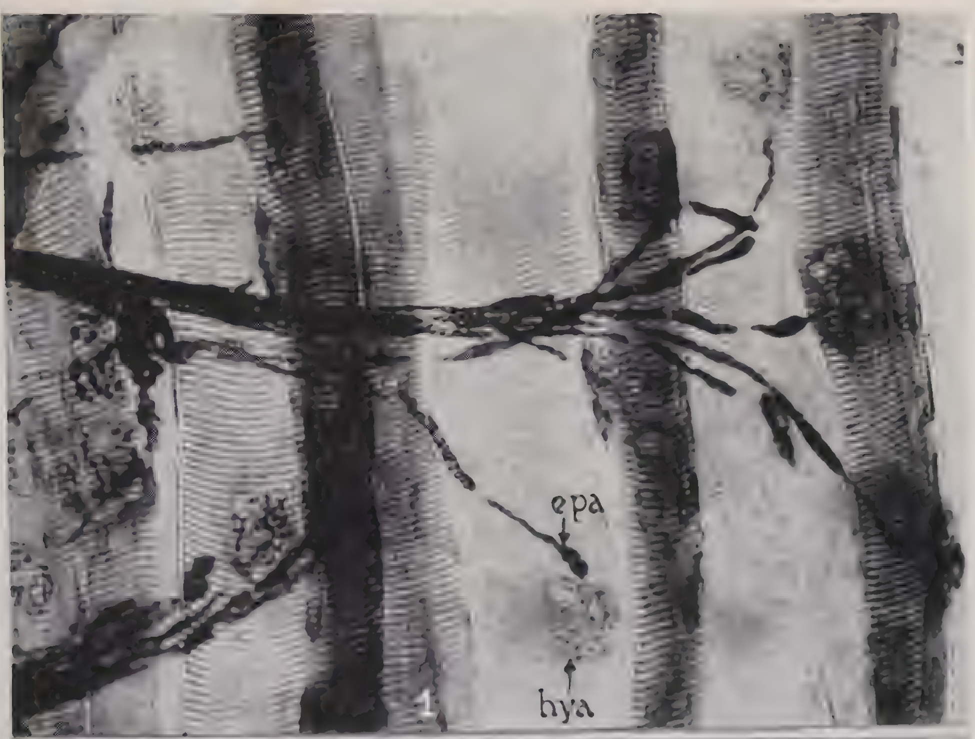
PLATE 1

EXPLANATION OF FIGURES

1 Photomicrograph of sprays of medullated nerve fibers and motor end plates in the normal, teased, fifth intercostal muscle, albino rat no. 38. The fractional contraction is manifested by (1) dark relaxed muscle fibers with coarse darkly stained cross striations and retracted nerve plates surrounded by the granular sole plate of Kühne and, (2) light contracted muscle fibers with fine lightly stained cross striations and expanded end plates with reduced amount of sole plate. These normal teased fibers of the fifth intercostal muscle were obtained before the rat was subjected to carbon dioxide. Gold chloride tecrnique. × 500. (epa, epilemmal axon; hya, hypolemmal axon).

2 Photomicrograph of sprays of medullated nerve fibers and expanded motor end plates in the teased, tenth intercostal muscle from the same albino rat as above (no. 38) after stimulation with carbon dioxide for 3 minutes and acceleration of the rate of respiration from 60 to 200 per minute. Certain groups of stimulated muscle fibers have become more uniform in their internal structure and exhibit about the same phase of contraction. The stimulated motor nerve plates are expanded in the widened and contracted muscle fibers. The surface area of the stimulated and expanded end plate is increased. The granular sole plate of Kühne has disapperead in the greatly expanded plate, as is seen in the last muscle fiber to the right. There are thirty double cross striations related to this greatly expanded nerve plate. There are only ten to fifteen coarse striations related to the retracted nerve plates in the relaxed muscle fibers of the relatively normal muscle, (fig. 1). Gold chloride technique, × 500. (The magnifications given for the figures on the plates 1, 2, and 3 were computed for the final reduction of the plates to 5 inches in width).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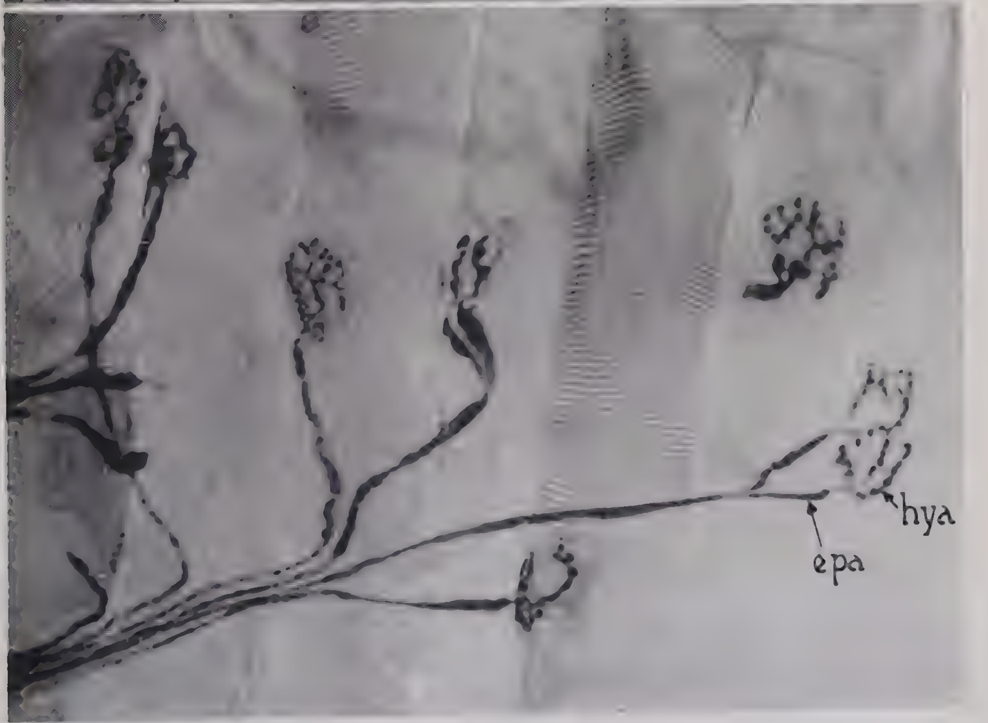
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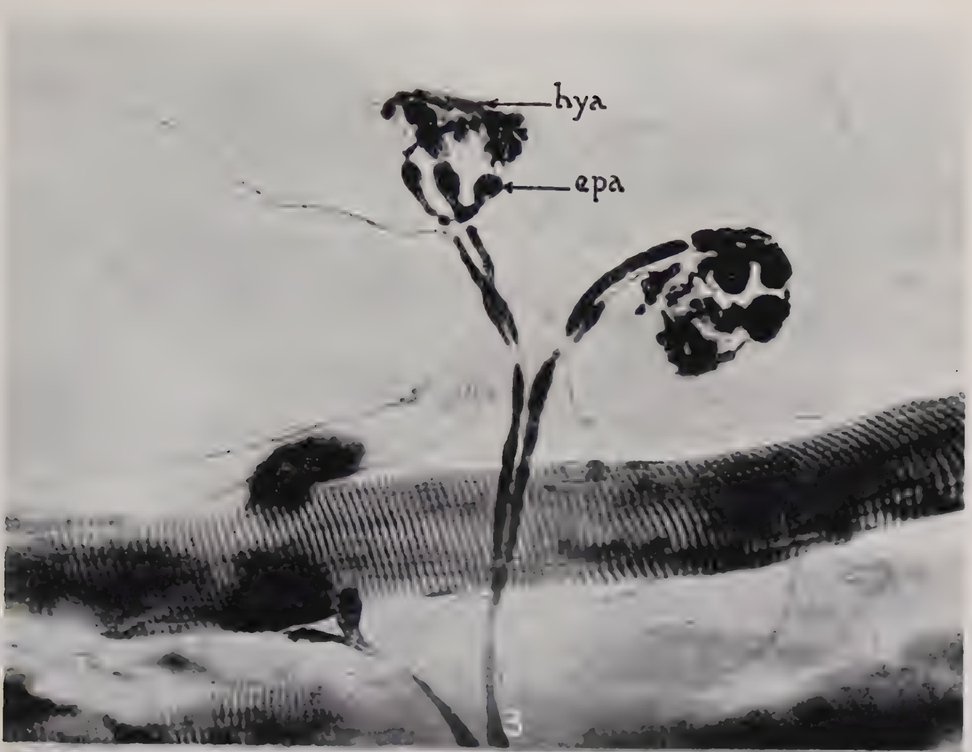
PLATE 2

EXPLANATION OF FIGURES

3 Photomicrograph of sprays of medullated nerve fibers and motor end plates in teased intercostal muscle fibers of the albino rat starved for 5 days. Enlarged dilatations of the epilemmal axons are beginning to appear concurrently with a retraction of the hypolemmal branches of the axon. The epilemmal dilatations vary from 15 to 40 microns in diameter. Fractional contraction of the muscle fiber is still present, manifested by the retraction of the motor end plate in the relaxed and darkly stained muscle fiber and partial expansion of the end plate in the lightly stained contracted ones. Gold chloride technique, × 500. (epa, epilemmal axon; hya, hypolemmal axon).

4 Photomicrograph of a single medullated nerve fiber with three motor end plates in the intercostal muscle of the white rat starved for 6 days. There is increased enlargement of the epilemmal axons and progressive retraction of the hypolemmal ramifications. The epilemmal axons appear to form distended retention cysts of the substances that have a strong affinity for gold. The cross striations are fine and closely spaced. Gold chloride technique, × 500.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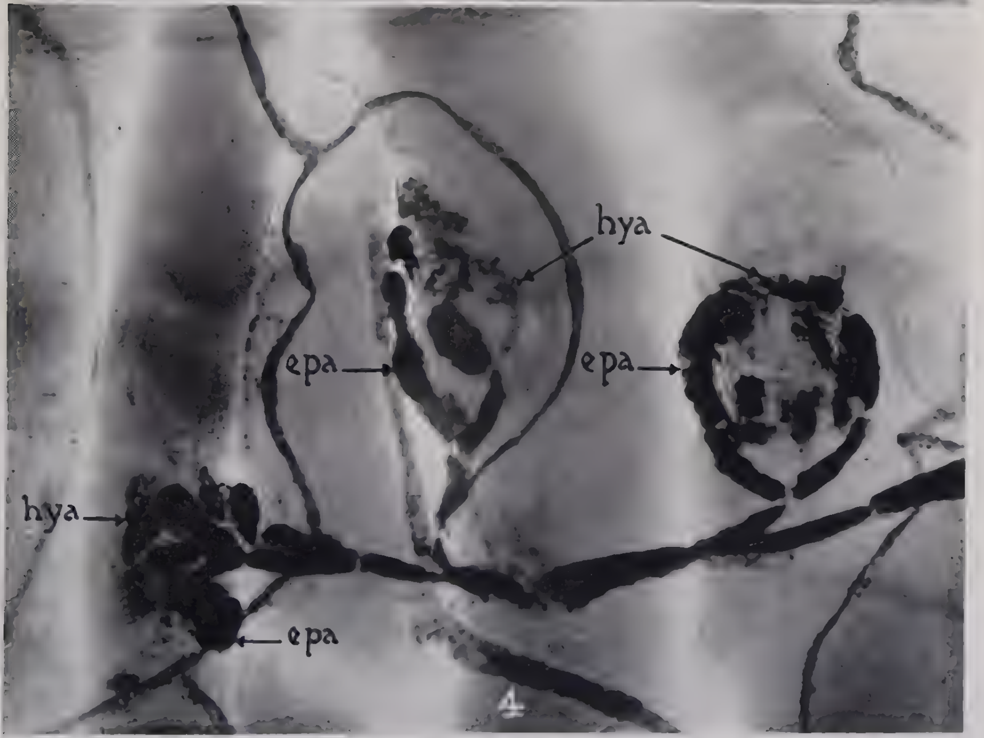
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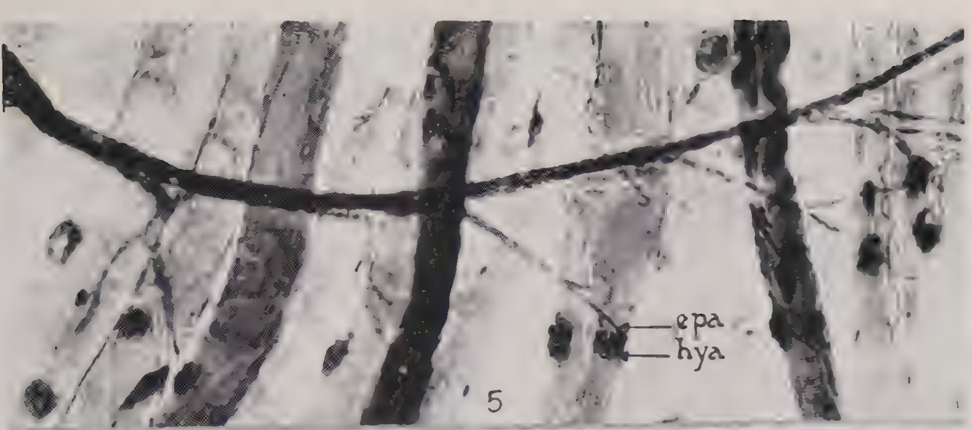
PLATE 3

EXPLANATION OF FIGURES

5 Photomicrograph of sprays of normal medullated nerve fibers and end plates in the intercostal muscle fibers of the albino rat. The dark relaxed and light contracted muscle fibers are intermixed in the fractional contraction of this muscle. These normal motor end plates vary from 24 to 55 microns measured in the long axis of the muscle fiber. The axons vary from 1 to 10 microns in diameter. Gold chloride technique, × 200. (epa, epilemmal axon; hya, hypolemmal axon).

6 Sprays of medullated nerve fibers and motor end plates in intercostal muscles 48 hours after the start of experimental acute inanition. Many of these end plates are expanded when the respiratory rate increases and vary from 24 to 90 microns measured in the long axis of the muscle fiber. The axons vary from 1 to 15 microns in diameter. Gold chloride technique, × 200.

7 Sprays of medullated nerve fibers and retracted motor end plates in intercostal muscle fibers of the white rat 7 days subsequent to the beginning of acute starvation. There is great retraction of the hypolemmal branches of the axon and expansion of the epilemmal beaded axons. Some of the epilemmal enlarged axons have distended terminal bulbs without any processes that penetrate the sarcolemma. The distended axons vary from 1 micron in the zone of constriction to 30 microns in that of the bulbous expansion. There is a progressive loss of the dark and light fiber types of muscle (compare the normal, fig. 5) to the seventh day of acute starvation (fig. 7). Gold chloride technique, × 200.



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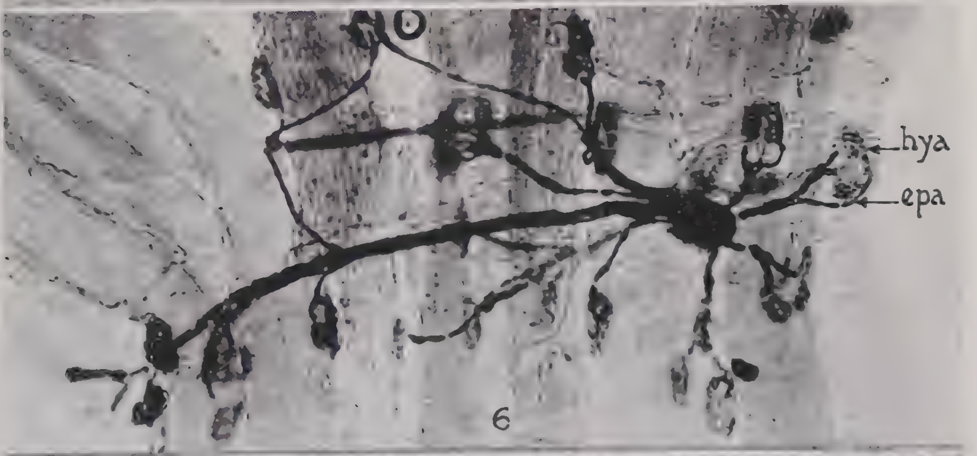

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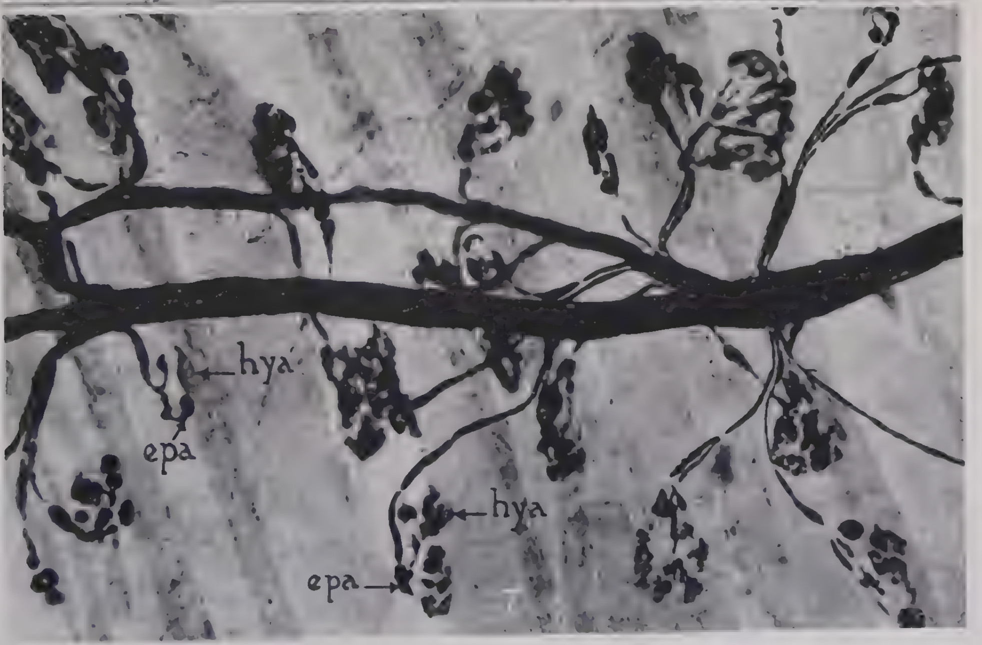
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INFLUENCE OF TESTOSTERONE PROPIONATE ON THE ADRENALS AND TESTES OF HYPOPHYSECTOMIZED RATS [1] [2]

JAMES H. LEATHEM

Department of Zoology, Rutgers University, New Brunswick, New Jersey

It is well known that after hypophysectomy in the rat the adrenals and testes atrophy and lose weight. By the administration of adequate amounts of androgenic substances it is possible to maintain spermatogenesis and testis weight but the adrenal glands become atrophic (Walsh, Cuyler and McCullagh, '34; Nelson and Gallagher, '36; Cutuly, McCullagh and Cutuly, '37; Nelson and Merckel, '38). A partial maintenance of adrenal weight following hypophysectomy has been observed when testosterone propionate was administered to immature male rats (Cutuly, Cutuly and McCullagh, '38; Leonard, '42) but in more recent experiments Cutuly ('42) was unable, apparently, to obtain this effect on the adrenals and described the glands as atrophic. Also, it appears that in immature ground squirrels, following hypophysectomy, the typical loss in adrenal weight is not prevented by androgens (Zalesky et al., '41).

In view of these contradictory observations the present experiments were undertaken to ascertain whether or not the length of the injection period is a determining factor in the partial maintenance of adrenal weight. Furthermore the androgenic action on spermatogenesis was studied in rats of 27 and 33 days of age since Cutuly ('42) has reported that spermatogenesis can not be stimulated in rats hypophysectomized before day 29 even though large daily dosages of testosterone propionate are administered.

MATERIALS AND METHODS

Immature male rats of the Long-Evans strain were used. Spermatids have not been observed before the thirty-seventh day of age. Animals were hypophysectomized when either 27 or 33 days old. Of the total of 131 immature male rats used, eighty-five were hypophysectomized and served either as treated or as control rats. Normal rats were used

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[1] Supported by a grant from the Penrose Fund of the American Philosophical Society.

[2] Grateful acknowledgment is made to Mr. Howard H. McDougall for valuable technical assistance.

as reference controls at the start of the experimental period as well as at the conclusion of the injection series.

The treated hypophysectomized rats received testosterone propionate (Perandren, Ciba [3]) as a single daily subcutaneous injection of 2.5 mg. (0.1 cc. oil) starting the day of hypophysectomy. Injections were continued for 10, 15 and 20 days when the starting age was 27 days and for 5, 10 and 15 days when the starting age was 33 days. Division of litters made possible, in many cases, the comparison of treated hypophysectomized and control rats with normal controls from the same litter. Normal and hypophysectomized rats serving as controls were never caged with androgen treated rats.

All pituitary capsules were serially sectioned, stained with Mallory's triple stain and examined microscopically. Data from animals exhibiting a pituitary fragment, no matter how small, were discarded.

At autopsy, a day after the last injection, fresh weights of the carefully dissected adrenals, testes and seminal vesicles (including the coagulating gland and any contained fluid) were taken. All testes and adrenal glands were prepared for histological examination after Bouin's fixation and staining with hematoxylin and eosin.

OBSERVATIONS

Adrenals

Testosterone propionate prevented to a variable extent the marked loss in adrenal weight usually occurring after hypophysectomy. In rats 27 days of age and receiving androgen for 10 days, the decrease in the weight of the adrenals was only slight. Adrenal weight averaged 8.4 mg. (range 7.3–9.7 mg.) as compared with 4.8 mg. (range 3.4–6.1 mg.) in non-treated hypophysectomized rats. The average adrenal weight of 27-day-old normal rats was 9.9 mg. It is evident that slight atrophy does occur with testosterone propionate. A further loss in adrenal weight was observed when the treatment was continued for 15- and 20-day periods although adrenal weight 15 days postoperatively was significantly greater in the treated than in the non-treated hypophysectomized rats (table 1). The number of rats treated for 20 days is too small to consider the results as significant.

Similar results were obtained using the 33-day-old rat. At this age the two adrenal glands averaged 14.2 mg. whereas 10 days after hypophysectomy these glands averaged 5.0 mg. (range 4.1–6.6 mg.). The hypophysectomized rats treated with androgen during this period, however, had adrenal glands which averaged 9.1 mg. (range 7.4–11.0 mg.) in weight. In this age group too, a steady decline in adrenal weight occurred despite hormone treatment but again the adrenals were heavier in the treated than in the non-treated hypophysectomized rats (table 1).

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[3] Testosterone propionate, Perandren, was generously supplied by Dr. E. Oppenheimer, Ciba Pharmaceutical Products, Summit, N. J.

TABLE 1

Influence of testosterone propionate on hypophysectomized immature male rats treated with 2.5 mg. daily.

NO. OF RATS	TREATMENT OF GROUP	BODY WEIGHT		AVERAGE WEIGHT OF ORGANS		
		Start	End	Testes	Sem. ves.	Adrenals
		gm.	*gm.*	*mg.*	*mg.*	*mg.*
	Hypophysectomized at 27 days of age					
5	Initial control (N.C.)		48.0	391.0	8.8	9.9
6	Hypo. T.p. × 10	61.0	61.0	379.0	271.0	8.8
6	H.C.	59.2	62.3	117.3	5.9	4.8
8	N.C.	52.1	99.6	667.7	18.8	15.0
11	Hypo. T.p. × 15	57.0	75.0	361.0	571.0	7.1
4	H.C.	54.5	64.0	87.0	6.0	3.5
5	N.C.	49.6	106.0	1028.0	33.5	15.2
2	Hypo. T.p. × 20	68.0	75.0	471.0	885.0	5.6
2	H.C.	62.0	58.0	80.0	5.7	3.3
2	N.C.	60.0	125.0	1221.0	58.0	18.0
	Hypophysectomized at 33 days of age					
5	Initial control (N.C.)		72.0	744.0	12.2	14.2
9	Hypo. T.p. × 5	84.1	78.7	789.0	96.1	10.5
11	H.C.	82.1	78.5	443.0	7.3	8.3
9	Hypo. T.p. × 10	75.1	76.5	660.8	348.3	9.1
11	H.C.	78.2	76.1	199.9	6.3	5.0
9	N.C.	73.0	116.0	1072.0	24.4	16.7
8	Hypo. T.p. × 15	83.0	80.3	757.4	707.7	7.1
6	H.C.	76.3	71.8	200.6	6.7	4.3
5	N.C.	70.0	126.0	1200.0	38.2	16.2

H.C. = hypophysectomized control. N.C. = normal control.

In cases where hypophysectomized littermates could be compared, the rats receiving testosterone propionate had heavier adrenal glands than the non-treated rats with but three exceptions. These exceptions included one pair in which the gland weights were identical and two other pairs among the rats treated for 5 days.

Atrophy of the adrenal glands following hypophysectomy involves the cortex. As anticipated, this portion of the adrenal was less atrophic in the androgen treated animals.

Testes

Rats hypophysectomized at 27 days of age were at least 10 days removed from the earliest time when spermatids are observed in the seminiferous tubules of our normal animals. In the absence of injections the testes exhibited the typical atrophic interstitial tissue and seminiferous tubules, the latter being devoid of spermatids. After ten daily injections a very few spermatids were observed in two of six rats. Spermatids were observed in the testes of four of eight normal animals (37 days old) but spermatozoa were absent.

Testosterone propionate did not maintain the seminiferous tubules in normal condition despite the maintenance of testis weight. Many tubules exhibited desquamated cells in the lumina even in the animals where a few spermatids were seen. Apparent tubular size was greater in the androgen treated rats than in the hypophysectomized controls but much larger tubules were observed in the normal rat.

When the treatment period was extended to 15 days, spermatids were observed in the seminiferous tubules in three of eleven rats. The positive results were not correlated with the largest testes. Testis weight was maintained, however, and the size of the seminiferous tubules exceeded those of the hypophysectomized controls. Spermatids and spermatozoa were present in the testes from all normal control animals.

A few spermatids were observed in the testes from one hypophysectomized rat treated with testosterone propionate for 20 days and the tubules were larger than those seen in hypophysectomized controls. In spite of the injections the seminiferous tubules had many desquamated cells in the lumina and exhibited a very loose cell arrangement, markedly disorganized. The epididymus contained only desquamated cells seemingly transported from the testes.

Rats hypophysectomized at 33 days of age were only a few days removed from the time when spermatids normally make their initial appearance in the testes and it was anticipated that induction of spermatogenic function could be more readily produced in this age group. After the administration of testosterone propionate for 5 days, all but one of the hypophysectomized rats had spermatids in the testes. Extending the injection period to 10 days, spermatozoa were present in four cases, spermatids in four cases and one case was negative. The spermatogenic activity in the androgen treated rats rather paralleled the type of activity observed in littermate normal control rats, although the degree of spermatogenic activity was less marked than in the normal rat. As indicated, one of the hypophysectomized rats failed to respond to androgen but only a few spermatids were observed in the testes from one of the two littermate normal control rats. The testes of all other normal controls contained spermatozoa.

Spermatozoa were observed in the testes of six out of eight hypophysectomized rats treated with testosterone propionate for 15 days. In some cases desquamated cells were present in the lumina of the seminiferous tubules but in one rat in which testis weight was the heaviest of any in the group, the testes appeared virtually normal. Those of normal controls contained spermatozoa.

While the testis weight of the hypophysectomized rats receiving androgen exceeded that of hypophysectomized controls, the hormone merely maintained the weight since the average testicular weight was comparable to that secured at the time hypophysectomy was performed.

Weight of the seminal vesicles, in the normal rats, increased somewhat during the experimental periods but in the hypophysectomized rats receiving testosterone propionate the seminal vesicles were markedly stimulated. With the longest injection periods, weights comparable to those of normal adult rats were obtained.

DISCUSSION

It is evident by injecting immature hypophysectomized rats with large amounts of testosterone propionate a partial maintenance of the adrenal weight can be obtained. However, as the length of the injection period is extended, a decrease in adrenal weight does occur despite injections. Leonard ('42), injecting immature hypophysectomized male rats with this androgen for 10 days, observed a partial maintenance of adrenal weight. Cutuly et al. ('38) obtained similar results in five rats treated for 7–15 days. Simpson, Li and Evans ('42), in a footnote, mention a similar action of this androgen. Cutuly ('42) later reported the adrenal glands of hypophysectomized immature male rats receiving testosterone propionate to be atrophic; but virtually all animals were treated for at least 20 days. In view of the steady decline in adrenal weight resulting after hypophysectomy, even though the androgen is administered, it is possible that a 20-day experimental period would fail to exhibit significant changes in adrenal weight. It is evident from our data that 20 days postoperatively the adrenals were atrophic since they averaged 5.6 mg. in the treated rats but they were less atrophic than in the hypophysectomized controls whose adrenal weights averaged 3.3 mg. These data are not significant due to the small number of rats used but this does not detract from the differences in adrenal weight observed with shorter periods of treatment. The failure of Zalesky et al. ('41) to observe an effect on adrenal weight in hypophysectomized immature ground squirrels could be due to the length of the injection period and the dosage, as well as a species difference.

The formation of a few spermatids in the seminiferous tubules of rats hypophysectomized at 27 days of age and treated with testosterone propionate was observed in six of nineteen animals. Previous investigations have failed to reveal any stimulation of the seminiferous tubules in rats when hypophysectomized before day 29. Cutuly et al. ('38) initially investigated the effect of androgens on rats hypophysectomized before 29 days of age, using a 7–15-day injection period, and obtained no stimulation of the tubules. However, the maximum daily dose was 0.3 mg. — considerably less than our dose of 2.5 mg. Negative results were also obtained in three rats treated with 3 mg. of testosterone propionate daily for 20 days (Cutuly, '42). In view of the small number of positive results obtained in our series in this age group it would appear that the chance that Cutuly might have obtained a positive result was small. Furthermore, as Cutuly ('42) has observed, an injection period of 20 days leads to a disorganization of cells in the seminiferous tubules.

In twenty-one of twenty-five rats hypophysectomized at 33 days of age and treated with testosterone propionate for 5 to 15 days, the testes exhibited spermatids and spermatozoa. Desquamated cells were observed in the lumina of some seminiferous tubules, indicating that the testis stimulation was not entirely normal, although other tubules were in excellent condition.

Although several cases of testis stimulation by testosterone propionate have been observed in the rat hypophysectomized when 27 days old it is evident, as has been proposed by Cutuly & Cutuly, '40, and Cutuly, '42, that an age factor is involved since only spermatid formation could be induced. On the other hand spermatozoa were quite readily induced by the androgen when the age at hypophysectomy was 33 days.

SUMMARY

A partial maintenance of adrenal weight in hypophysectomized immature male rats for at least 15 days can be obtained by the injection

of large amounts of testosterone propionate. As the length of the injection period is extended decrease in adrenal weights occurs, despite androgen treatment. In some rats hypophysectomized at 27 days of age the formation of spermatids can be induced by testosterone propionate, but no spermatozoa are formed. Extended treatment results in tubular damage. In rats hypophysectomized at 33 days of age and treated with testosterone propionate formation of spermatozoa may be observed.

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EFFECT OF ADRENOCORTICOTROPIC HORMONE (ACTH) ON THE ANTERIOR PITUITARY OF THE ADRENALECTOMIZED YOUNG MALE RAT

ALEXEI A. KONEFF
Division of Anatomy, Medical School, and Institute of Experimental Biology, University of California, Berkeley[1]

ONE PLATE (ELEVEN FIGURES)

In a previous communication (Koneff, '44) it was reported that injection of adrenocorticotropic hormone into normal young male rats caused diminution in weight of the hypophysis, definite decrease in size of basophils accompanied by loss of granular material, and changes in the nucleus and cell organelles. These alterations were interpreted as indicative of retarded or depressed functional activity of the basophils. No significant changes were observed in the acidophils.

Recent biological studies conducted here have indicated that the effect of ACTH in adrenalectomized rats is different from that in normal males.[2] Namely, it does not retard the body weight increase in the absence of the adrenals, causes no decrease in thymus or thyroid weight (Simpson, Li, Reinhardt and Evans, '43) and does not alter histologically the testis in the adrenalectomized animal. It was of interest, therefore, to see whether the morphological appearance of the anterior pituitary would also differ in normal and adrenalectomized ACTH-treated rats.

MATERIAL AND METHODS

As in the previous investigation of the effect of ACTH on the anterior hypophysis, young male rats were used. The rats were adrenalectomized at 26 days of age and injections of pure ACTH (Li, Evans and Simpson, '43) were begun immediately. One milligram doses (divided into three injections) were given daily intraperitoneally for 30 days.

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[2] The report from the Institute concerning the biological effects of the ACTH in young adrenalectomized rats will be published separately.

All adrenalectomized rats were supported by 1% sodium chloride in their drinking water. Only animals in which adrenalectomy was complete were included in this analysis (completeness determined by careful search of site of operation at autopsy and section of any suspicious fragments of tissue).

Three groups of male rats were studied:

Group 1 consisted of nine rats which were adrenalectomized, treated with ACTH and sacrificed on the fifty-sixth day of life.

Group 2 consisted of ten rats which were adrenalectomized, untreated and sacrificed on the fifty-sixth day of life.

Group 3 consisted of ten normal rats of 56 days of age. The pituitaries of these animals had also been used in the previous investigation as controls for normal males injected with ACTH (Koneff, '44).

HISTOLOGICAL AND CYTOLOGICAL METHODS

For general histological study, pituitaries from four rats in group 1 and 2, and six in group 3, were fixed in Zenker-formol and after celloidin embedding, sectioned at 4 micra. The modified Mallory-Azan technique was used as a staining method (Koneff, '38).

Five pituitaries from rats in group 1, six glands from rats in group 2 and four in group 3 were treated according to the Altmann-Masson method and the Nassonov-Kolatschev technique (as adapted by Severinghaus, '32) for the purpose of demonstrating mitochondria and the Golgi apparatus respectively.

RESULTS

Anterior pituitary of adrenalectomized control rats

Both acidophils and basophils in the pituitaries of adrenalectomized rats showed changes when contrasted with the respective types of chromophil cells in the normal gland. Even preliminary examination with moderate magnification revealed changes in the acidophils. Although no cell counts were made there was an obvious decrease in the number. Their size was significantly diminished (see table, M_3 vs. M_2). The granular material in a large proportion of these cells was markedly reduced. It should be noted in connection with the changes in size and the degranulation of acidophils that many cells, ordinarily called chromophobes, were present which could be identified as acidophilic chromophobes on the basis of the Golgi apparatus and other morphological characteristics. The basophils in the pituitaries of adrenalectomized rats did not show such pronounced alterations as those noted in the acidophils. The majority of the basophils closely approximated the normal in structural characteristics. There were no changes in Golgi apparatus and mitochondria which would indicate changed functional activity. It should be emphasized however, that the average size of the basophils was significantly reduced (see table, M_6 vs. M_5).

TABLE 1

Effect of ACTH on the size of acidophils and basophils of adrenalectomized rats.

GROUP NO.	EXPERIMENTAL CONDITIONS	NO. OF RATS	CELL SIZE IN PLANIMETRIC UNITS[1]			
			Acidophils		Basophils	
			Mean	SR[2]	Mean	SR[3]
1	Adrenalectomized on 26th day of life, supported with NaCl and treated with ACTH; age 56 days	4	(M_1) 161±8[2]		(M_4) 309±10[2]	
2	Adrenalectomized on 26th day of life, supported with NaCl, untreated; age 56 days	4	(M_2) 156±7	M_2 vs. M_1=0.50	(M_5) 278±8	M_5 vs. M_4=2.38
3	Normal; age, 56 days	6	(M_3) 195±5	M_3 vs. M_1=3.77 M_3 vs. M_2=4.33	(M_6) 360±7	M_6 vs. M_4=4.25 M_6 vs. M_5=7.45

[1] Area occupied by camera lucida tracings of 100 cells expressed as

[2] S E (of mean) $= \dfrac{\text{S D}}{\sqrt{\text{n} - 1}}$

[3] S R; Significance ratio was calculated by the formula: $\dfrac{\text{Mean}_1 - \text{Mean}_2}{\sqrt{(\text{S E Mean}_1)^2 + (\text{S E Mean}_2)^2}}$

The difference of the means was considered statistically significant if the SR was greater than 3.0.

In a small number of basophils, degenerative changes were noted. In some of these cells the stainable granular material was not uniformly distributed throughout the cytoplasm as in normal cells, but was confined to the periphery of the cell body and occurred in coarse, darkly stained clumps. The perinuclear area in this case was light and somewhat reticular. A few basophils showed vacuolation. In this case, the peripheral portion of the cytoplasm was first affected; in more advanced stages, the vacuolation occupied a considerable portion of the cell body. It should be noted however, that a few basophils were present, which on casual observation, appeared normal, but which possessed a Golgi apparatus which was moderately hypertrophied and of increased complexity.

The changes just described for the pituitaries of rats adrenalectomized at 26 days of age are essentially the same as those previously reported from this laboratory (Koneff, Holmes and Reese, '41) in the glands of males, adrenalectomized at 60 days of age and supported by sodium chloride for a period of 45 days.

Anterior pituitary of adrenalectomized rats treated with ACTH

In the pituitaries of the injected group, as in the glands of adrenalectomized controls, both chromophil cells were altered from normal. In acidophils, the morphological changes including the finer cytological characteristics, were the same, qualitatively and quantitatively as those described in acidophils of the adrenalectomized controls, the changes being essentially a matter of size decrease and degranulation. The acidophils of the injected rats were slightly smaller even in operated controls, but this was not significant statistically (see table, M_2 vs. M_1). On the other hand, the basophils in the pituitaries of the adrenalectomized ACTH treated rats differed in several respects from those in the glands of the adrenalectomized control animals. Firstly, the young basophils were increased in number. Many small round cells were present, possessing a dark, basophilic cytoplasm, large, well-defined nuclei and a basophilic type of Golgi apparatus, which should unquestionably be considered to represent a crop of young basophils. The young basophils can usually be observed in normal pituitaries, as well as in those of adrenalectomized controls, but are less frequent than in this group; here the percentage of these cells called young basophils was sometimes as high as 15%.

Careful examination of the pituitaries showed a second variety, constituting 5 to 7% of all basophils. These cells, already noted in glands of adrenalectomized controls showed the disappearance of the stainable granular material in the perinuclear area and the clumping of the basophilic material at the periphery of the cell. This type of alteration was far more pronounced in injected than in control adrenalectomized rats (fig. 8) and was noted in a larger percentage of cells. In some of the basophils of this category, various degrees of nuclear degeneration and alteration in cell organelles was also present, such as clumping of mitochondria.

The largest group of basophils, in some glands reaching 35% of all basophils, showed another type of degenerative change, involving vacuolation of the cytoplasm. In so far as it was possible to reconstruct the succession of events, the alteration probably began with the appearance of a few small vacuoles in the peripheral portion of the cytoplasm, and proceeded unevenly toward the nucleus. Some of the vacuoles coalesced, thus forming larger vacuoles filled with homogeneous material, dark or light blue in staining reaction. In many instances, a secondary vacuole, colorless and sharply outlined, appeared in this homogeneous material, giving the impression that some substance previously occupying this vacuole was dissolved in the process of fixation or dehydration. The nucleus and Golgi apparatus were crowded into the center or pushed to the periphery of the cell body by the accumulation of vacuoles and both were distorted in shape (figs. 9 and 10). In the final stages the nucleus was irregular in outline, compact and deep staining and the cytoplasm was obviously disintegrating (fig. 11). It will be remembered that only a few of the basophils of adrenalectomized controls were vacuolated. The number of vacuolated cells and the extent to which vacuolation has progressed in the basophils of the injected group, explains the slight, average, size increase of basophils in this group (see table, M_5 vs. M_4).

In some apparently normal basophils or in those revealing only the initial stages of vacuolation, there was evidence for a considerable degree of heightened activity. This was manifested by one or more of the following characteristics, increased cell size, various degrees of granular depletion, prominent mitochondria or hypertrophied Golgi apparatus (figs. 6 and 10). It appeared as though these basophils were making an effort to compensate for the function lost by the degenerating cells.

The chromophobes in the pituitaries of adrenalectomized ACTH treated rats were numerically increased and, as in adrenalectomized controls, this was due to degranulation of acidophils as far as could be determined from general as well as specific staining methods.

DISCUSSION

In an attempt to evaluate the above mentioned findings in the glands of adrenalectomized ACTH-treated rats, one must consider whether the changes are directly related to the adrenalectomy. If so, are they related to the general physiological condition of the adrenalectomized animal, or are they secondary to alteration of other endocrine organs, and finally are the effects due in part or entirely to action of the hormone on the parenchyma of the pituitary?

It seems improbable that the effect of the ACTH on the anterior pituitary of adrenalectomized rats was mediated through the testes or thyroids inasmuch as no deviation from normal was found in these organs. In fact, it is strange to have such marked alterations in the pituitary not reflected in changes in thyroid or testis but it is possible that regardless of the degeneration of some basophils, sufficient numbers of these cells remain to assure adequate support of these other endocrines.

The body weight change of adrenalectomized ACTH-treated rats and their controls was approximately the same when maintained on salt in the drinking water.

It has been previously reported from this laboratory (Koneff, Holmes and Reese, '41) that the pituitary changes resulting from the adrenalectomy of 60-day-old male could be prevented to a large degree by the sodium chloride therapy. It should be emphasized, however, that sodium chloride did not maintain the anterior pituitary in its completely normal state. Both chromophil cells were never quite as large in the glands of animals maintained on salt as in those of normal control rats of the same age. The acidophils showed greater than normal degranulation and reversion to the chromophobe state, while in a few basophils the initial stages of degeneration or signs of heightened functional activity were observed. The same deviation from the normal morphology of the anterior pituitary was also detected in the adrenalectomized controls as well as in the ACTH-treated animals of the current series. Therefore, only the severer degenerative changes involving the cytoplasm, the nucleus, and the cell organelles characterizing adrenalectomized ACTH-injected rats are to be considered as effects of the hormonal injections. In other words, one can readily see that chronic injection of ACTH into young adrenalectomized male rats does not modify the characteristic nature of the pituitary acidophils of this animal. One can also see that, contrary to this lack of response on the part of the acidophils, the basophils in the ACTH-treated rat's pituitary showed constant and conspicuous degenerative changes.

The experiments with ACTH-injected, normal male rats (Koneff, '44) showed that the prolonged injections do not alter appreciably the acidophils but cause a significant size decrease of the basophils, marked diminution in granular content of the cytoplasm, reduction in size of the Golgi apparatus and number of mitochondria in these cells. These alterations were interpreted as being indicative of a depressed or retarded functional activity of the basophils. There was no evidence that this effect of ACTH on the pituitary cells was mediated through testes or thyroid and the possibility was considered that detectable changes were due to a direct effect of the hormonal injections on the anterior pituitary.

In the present study of the effect of ACTH injections on the pituitaries of adrenalectomized rats, there also was no significant effect on the acidophils while the other type of chromophil cells — the basophils — showed considerable alteration. Here, in adrenalectomized rats again, there was no evidence of the mediation of the effect of hormonal injections through testes or thyroids, and, moreover, in the present experiment, the possible influence of the highly stimulated adrenal cortex on the pituitary was eliminated. Therefore, the present study seems to corroborate the previously expressed suggestion that the effect of the ACTH might be considered as a direct one on the parenchyma of the pituitary. One might even postulate that the basophils are participating in the production of the ACTH inasmuch as they are the only chromophil cells of the pituitary that manifested appreciable changes following the hormonal injections. This assumption is in accord with the recent findings of Smelser ('44), who demonstrated greater concentration of adrenotropic hormone in extracts of tissue taken from the central basophil-rich zone of the anterior pituitary of a beef, than in the peripheral acidophil-rich portion of the gland.

CONCLUSIONS

1. Changes were observed in both types of chromophil cells of the pituitary of adrenalectomized male rats, maintained on sodium chloride in drinking water and injected with ACTH.

2. In the acidophils, these changes (decrease in number, diminished size and degranulation) were the same as those found in the glands of adrenalectomized, uninjected control rats and therefore could not be regarded as a result of the ACTH treatment.

3. In the basophils, the outstanding change observed in a great number of cells was a degenerative change involving the cytoplasm, the nucleus and the cell organelles. The second feature was the presence of a crop of young basophils. Inasmuch as such changes were seen rarely in the basophils of the adrenalectomized control rats, they are considered as the direct effect of ACTH injections. This conclusion seems justifiable in so far as there was no indication that the effect of ACTH was mediated through the other endocrine glands studied — the testes or thyroids.

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PLATE 1

EXPLANATION OF FIGURES

Photographs of figures 1, 2 and 3 were taken with 4 mm. objective; magnification × 400. Mallory-Azan stain.

Photographs of figures 4 to 11 were taken with 2-mm. objective; magnification × 900. 4 and 6 Nassonov-Kolatschev preparations; 5, 7 to 11 Mallory-Azan stain. A key to figures 4 to 11, showing position of nucleus (N), Golgi apparatus (G) and vacuoles (V) is given opposite plate 1.

1 Field selected from a section of the anterior pituitary of a normal male rat. Note general size and distribution of acidophils. Note normal granulation of these cells.

2 Field selected from a section of the anterior pituitary of an adrenalectomized rat supported by 1% sodium chloride in drinking water. Note changes in size and granulation of the acidophils.

3 Field selected from a section of the anterior pituitary of an adrenalectomized-ACTH treated rat. Note general similarity of the acidophils in figures 2 and 3. Note presence of vacuolated basophils.

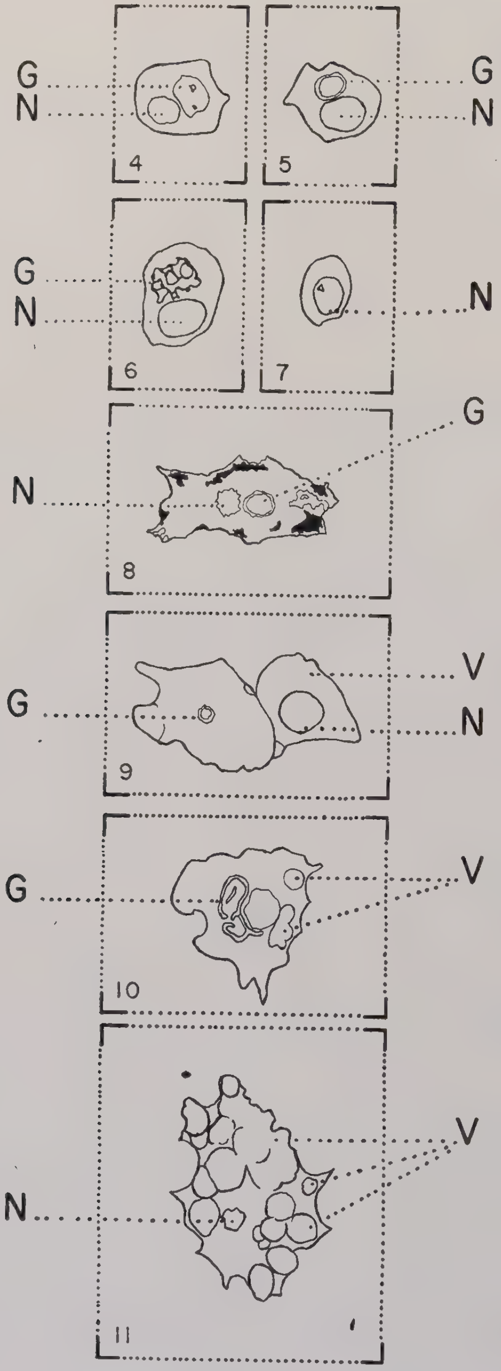
4 and 5 Basophils of a medium size from pituitary of normal rat. Note the size and shape of the Golgi apparatus.

6 Basophil from pituitary of adrenalectomized rat treated with ACTH. Note change in size and shape of the Golgi apparatus; compare with figures 4 and 5.

7 Basophil of a very small size. This variety of basophil cells was found in the pituitaries of adrenalectomized ACTH-treated rats.

8 Basophil showing clumping and peripheral concentration of the basophilic material in the cytoplasm.

9, 10 and 11 Basophils from the pituitaries of adrenalectomized ACTH-treated rats. Note a significant increase in cell size and vacuolation of the cytoplasm. Note pyknotic condition of the nucleus in figure 11.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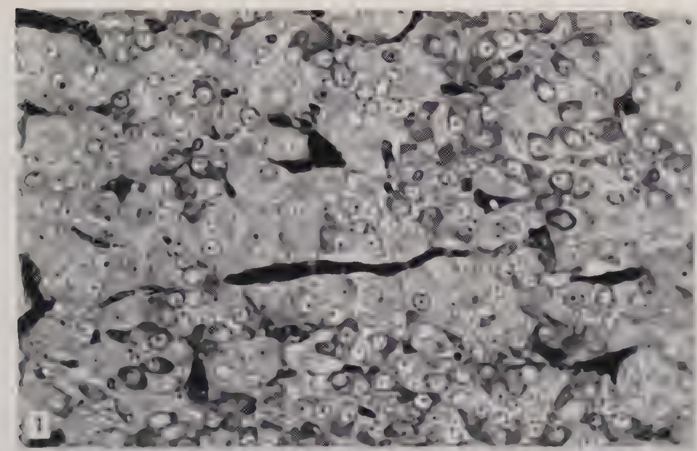
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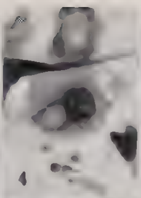
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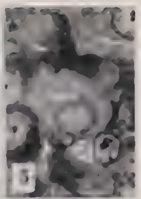
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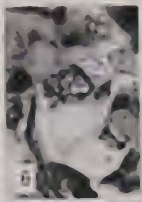
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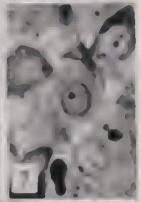
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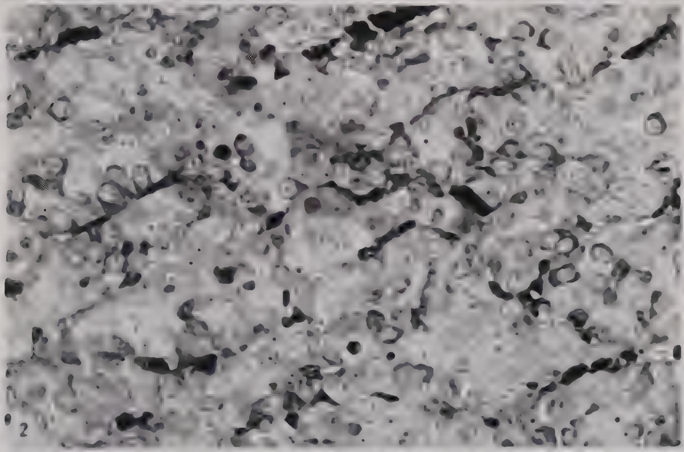
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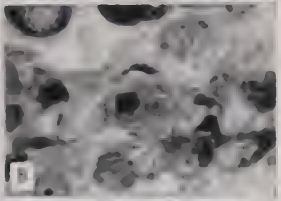
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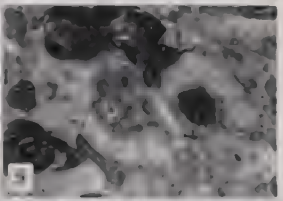
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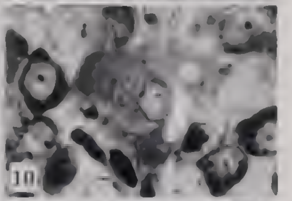
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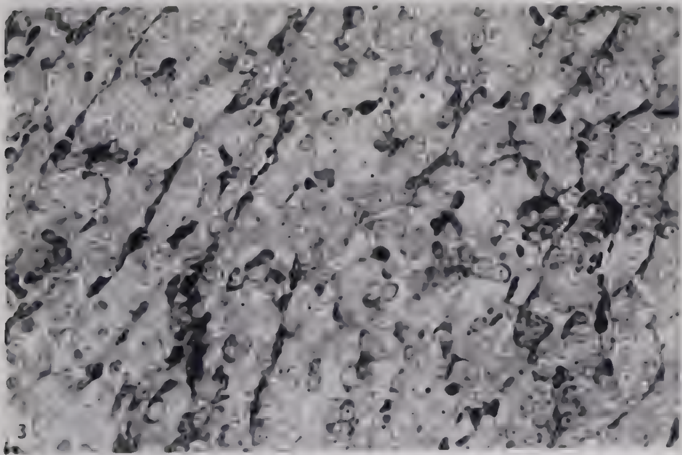
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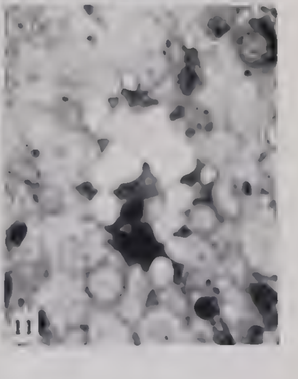
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BODY WEIGHTS AND ORGAN MEASUREMENTS IN RELATION TO AGE AND SEASON IN RING-NECKED PHEASANTS[1]

C. M. KIRKPATRICK

Department of Forestry and Conservation, Purdue University, Lafayette, Indiana

SIXTEEN FIGURES

A tremendous amount of information has been accumulated from technical studies of wildlife ecologists. However, a large percentage of this information deals with wild animals in relation to their environments. Although a decade ago Leopold ('33) emphasized the importance of physiological research to the field of game management, fundamental studies of growth, nutrition, and reproduction have largely failed to keep abreast of the ecological knowledge. This circumstance resulted because the field worker had neither equipment nor techniques to investigate the physiological problems he encountered, while the laboratory technician was not aware of the problems. Therefore, the reaction of the wild organism to its environment was often observed to be somehow related to the physiology of the organism, but even normal physiological processes remained problematical.

As part of a cooperative agreement between the Purdue University Agricultural Experiment Station and the Indiana Department of Conservation, some basic growth and development studies in ring-necked pheasants (Phasianus colchicus torquatus) have been possible. The Department of Conservation supplied the necessary quantities of birds for an Agricultural Experiment Station project, the object of which was to investigate in ring-necked pheasants the normal body growth, and developmental changes in reproductive and other organs. This project was carried out on pen-reared birds, permitting full control of environmental factors.

MATERIALS AND METHODS

On May 20, 1941, 400-day-old pheasant chicks were allotted to this work. The parents of the chicks were the regular breeding stock on the Jasper-Pulaski State Game Farm. As soon as the birds were removed from the hatcher, 100 of them were taken to Lafayette, about 55 miles south of the game farm. Excepting this difference in location, the separated groups of birds were from that time onward treated in the same manner as regards feeding and confinement. Periodic checks revealed very little difference in the growth rates of the separated groups. At 2 weeks of age, all chicks were wing-banded.

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[1] Journal Paper no. 154, of the Purdue University Agricultural Experiment Station, the Indiana Department of Conservation cooperating. The data in this article were used in a thesis presented by the author to the University of Wisconsin Graduate School in partial fulfillment of the requirements for the Doctor of Philosophy degree.

At about 3 months of age, the pheasants were transferred from their brooder runs to large holding pens. The wings of all birds were clipped to reduce mortality from flying within the pens. At frequent intervals between June 2, 1941 and May 25, 1942, a number of pheasants were selected at random from the Lafayette flock for autopsying. The Lafayette flock was replenished by several transfers of game birds. On June 15, 1942, all the remaining game farm birds were transferred to Lafayette. The only data reported in this paper taken after June 15, 1942, are live weights. Until that date, all the pheasants had been fed a commercial game bird feed. After that date, however, the entire flock was changed to a dry mash ration. The commercial feed and the mash were of approximately equal nutritive value.

Some pheasants were weighed within 24 hours after they had been removed from the hatcher, and at about 5-week intervals thereafter. Starting in December, 1941, bursae measurements were taken from each bird at the time of weighing, using the technique described by Kirkpatrick ('44). In preparation for weighing, the pheasants were driven into traps, netted, and placed in burlap covered crates which induced quietness and reduced injuries to a minimum. Each pheasant was weighed individually in a cardboard box which was counter balanced by means of a compensating beam on the scale.

Autopsy data were collected from a total of 177 birds. The birds to be autopsied were picked at random and their bursae measured. They were killed by breaking their necks and were weighed as soon as struggling had stopped. Immediately after weighing the head was removed and the body was hanged by the feet to allow drainage of the blood from the body.

All organs of less than 1 gm. were weighed on an analytical balance. Organs of a gram or more were weighed on a torsion balance sensitive to $1/10$ of a gram. Excepting the pituitary which was weighed as soon as removed, the small organs were collected in a moist chamber and were not weighed until all had been removed from the body.

The pituitary was removed and weighed first. It was dissected from the sella turcica, and the pia mater was removed under a binocular microscope. Next, the thymus was recovered by removing the skin from the body, exposing the thymus along the neck. Thymus tissue which occasionally adhered to the neck skin was carefully collected. Removal of the sternum and the heavy breast muscles exposed the viscera. The remaining organs were taken from the carcass in the following order: thyroid, heart, liver, spleen, pancreas, gonad, adrenal, kidney, lung, gizzard; the lengths of the intestine and caeca were measured last. The cloaca and bursa were removed together and examined, and these parts, with the gonads and other endocrine glands, were preserved in Bouin's fixative for later study.

As each organ was excised, it was gently rolled about upon paper toweling for the absorption of extravasated blood. The vessels entering the heart were severed close to their proximal ends. The heart, as well as the large vessels of the liver, were split open to remove clotted blood. The gall bladder was removed from the liver before the liver was weighed. The gizzard was weighed with its lining after being separated from the proventriculus and the intestine, and after removal of its contents and superficial fat. To avoid stretching the intestine, the mesenteries were carefully cut, permitting the intestine and caeca to lie straight on the table. In this position, they were measured with a meter stick.

RESULTS AND DISCUSSION

Body weights

As a result of the periodic weighing and autopsying, a series of average body weights and organ measurements for different ages of birds were accumulated. These measurements are plotted in relation to age in figures 1–16.[2] All of the curves for the average organ measurements are smoothed by making use of the process of moving averages. No curve is given for the average body weights taken at autopsy for it was found that the weight curves for the larger number of live birds (fig. 1) practically coincided with the smoothed curves of the autopsy weights.

The numbers of the pheasants from which the autopsy data were taken often appeared inadequate, suggesting that observed differences in the means of organ measurements for different ages may not be significant. Some of these observed differences, as they occur in relation to age, have been examined for significance using Fisher's ('41) *t*-test, with the results given in table 1.

[2] The author wishes to acknowledge the assistance of Mr. C. L. Pope in reproducing the graphs for publication. Numerical averages from which the curves are drawn may be found in the author's unpublished thesis, University of Wisconsin, 1943. Measurements from individual birds are preserved in the author's files.

Pheasant chicks weighed not more than 36 hours after hatching, and before they had eaten, averaged 21.8 gm. each. The ninety-eight chicks were weighed as a group. Milby and Henderson ('37) reported that nineteen pheasant chicks weighed at hatching averaged 21.9 gm. These figures are nearly 20% higher than the 18.2 gm. given by Leffingwell ('28) for five 5-day-old chicks. However, weight variations in newly hatched chicks may be attributed to their moisture content which is proportional to the incubator humidity (Romanoff, '34).

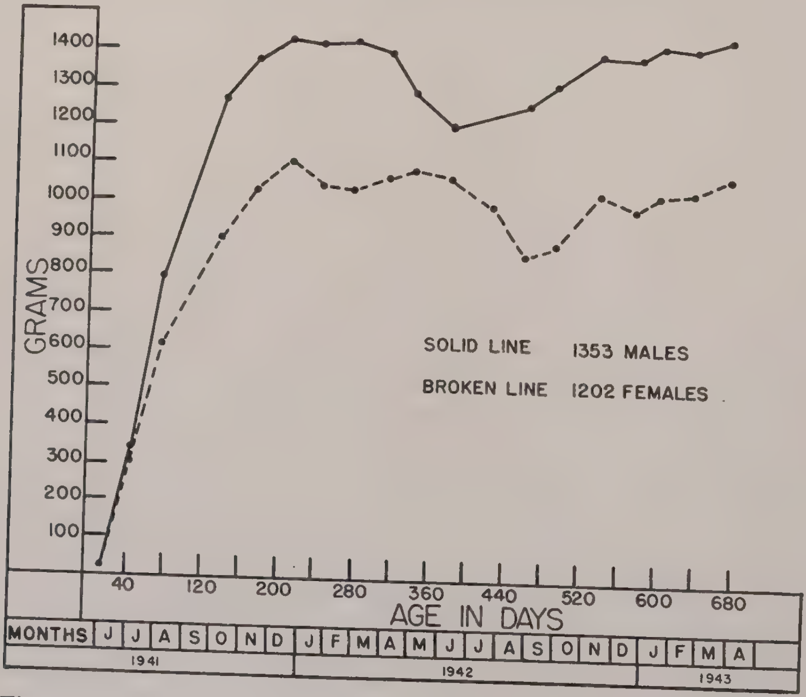

Fig. 1 Body growth and body weight changes in relation to age and season.

The period of fastest growth occurred from 42 to 138 days during which the average weights of both sexes increased nearly four times. Mosby and Handley ('43) found that the gain in weight of captive wild turkeys (Meleagris gallopavo silvestris) was greatest between 6 and 24 weeks (42 to 168 days). In pheasants, this rapid rate of body growth is correlated with significant increases in the thymus and pancreas of both sexes, male spleen and kidney, and increases in the lengths of intestine and caeca of both sexes as well as increased depths of their bursae (figs. 1, 6, 7, 11, 12, 14, 15, 16). After 138 days the momentum of growth slowed somewhat until the greatest average body weight was reached at 210 days in December. Then the cocks averaged 1428

TABLE 1

Results of tests for the significance of difference between means of organ weights or lengths grouped by periods for comparison.

COMPARISON BETWEEN GROUPED MEANS OF:	PERIODS OF DAYS FOR WHICH MEAN MEASUREMENTS ARE GROUPED	CALCULATED T VALUE	FISHER'S *t* VALUE (DIFFERENCE HIGHLY SIGNIFICANT AT .01 LEVEL; SIGNIFICANT AT .05 LEVEL)	
			.01 level	.05 level
Male and female thyroid weights	215–362	2.140		1.959
Male pituitary weights	109–151 and 165–236	1.574		2.479
Male thymus weights	87–116 and 130–172	27.140	2.080	
Female thymus weights	94–116 and 130–172	2.721		2.120
Male pancreas weights	81–191 and 215–306	11.826	2.575	
	285–306 and 334–362	3.461	2.878	
Female pancreas weights	87–191 and 215–306	7.709	2.575	
	285–306 and 334–362	2.706		2.552
Male liver weights	130–172 and 191–271	1.134		1.959
Male spleen weights	87–172 and 191–306	4.164	2.575	
Male kidney weights	116–172 and 191–306	5.987	2.575	
Male lung weights	94–172 and 191–285	0.866		1.959
Male intestine lengths	81–172 and 191–306	5.691	2.570	
Female intestine lengths	81–172 and 191–306	4.428	2.575	
Male caeca lengths	81–172 and 191–306	7.027	2.575	
Female caeca lengths	81–172 and 191–306	5.761	2.575	

gm. and the hens 1108 gm. Following these peaks, the weights of both sexes began to decline, although the loss by cocks was slight until April. From April to June there was a 13% loss of weight in cocks when they reached a low average of 1205 gm. in June. The hens lost weight rather sharply after December, but from February 22nd on there was a slight gain in weight with a tendency to plateau until June 5th. From June until August 22nd the average hen weight sustained a total loss of 19%. After August the hens and cocks gained rapidly up to March of the next year.

The weight behavior of artificially reared pheasants on controlled diet finds some parallels in both wild and domestic species. The rapid growth of pheasant chicks has been noted by Wight (Leopold, '33). His curve of semi-wild weights closely approximates the weight curve of pen pheasants used in this study. The weights of Buss' ('42) artificial released pheasants tend to be about 10% heavier from 42 to 154 days, but no data are given for older birds of this type. In ring doves (Streptopelia sp.), Riddle ('28 a) found an extremely rapid growth rate up to 3 months. In a comparative study Milby and Henderson ('37) showed that the growth rates of domestic geese and ducks exceed those of bronze turkeys, chickens, and pheasants, but these authors pointed out that pheasants reached their mature weights at a younger age than did the domestic species. The present data show that some artificially reared pheasants reach adult size and weight as early as 20 weeks, although the greatest average weight is attained at 30 weeks.

Seasonal variations in body weight have been noticed in many wild species by numerous observers. Leopold et al. ('43) in four winters of trapping found pheasant cocks and hens heaviest in December, with weights declining until spring. They also note the gain in hens in early spring simultaneous with the continued decline of the cocks. A sexual differential in seasonal weights, corresponding to that in pen-reared pheasants, has been noted in several wild gallinaceous species, namely red grouse (Lagopus scoticus) (Leslie, '12), bobwhite quail (Colinus v. virginianus) (Stoddard, '31), Gambel quail (Lophortyx gambeli) (Gorsuch, '34), and California quail (Lophortyx californica) (Sumner, '35).

In blue-winged teal (Querquedula discors), Bennett ('38) found adult females heaviest in spring and lightest during July and August. Drakes were heaviest during the winter and lightest during the spring flight and the eclipse (summer). In wild turkeys Mosby and Handley found the greatest weights in late winter and early spring, and the least weights were in late summer.

It is apparently typical for all birds to increase their body weight in fall and winter (Baldwin and Kendeigh, '38). This may be a response to increases in the size of the thyroid. Riddle and Fisher ('25) showed that the thyroids of pigeons increased in size during the winter, and stated that in vertebrates the thyroid normally enlarges in response to autumn and winter temperatures while decreasing with spring and summer temperatures. A possible explanation is that cold weather demands a greater production of heat and this is accomplished by increased function of the thyroid resulting in hypertrophy of that gland. The situation is reversed in spring and summer. Plausible as this hypothesis is, there does not seem to be a significant increase in the pheasant thyroid in the winter, although there is a suggestion of a decrease in the spring (fig. 3). Indeed, the period of maximum body weight of cocks occurs between 210 and 300 days during which period there are significant decreases in the pancreas, spleen, kidney, intestine, caeca, and bursa depth (table 1, figs. 7, 11, 12, 14, 15, 16). The maximum body weight of the females occurs between 210 and 243 days, but is correlated with decreases in the pancreas, intestine, caeca, and bursa depth.

The weight loss of cock pheasants (and other male birds) during the spring is attributed to the exigencies of the breeding period when much of their time is devoted to fighting among themselves and attention to hens. In pheasants, there is some evidence of increased adrenal size at this time implying increased adrenal activity (fig. 4).

No explanation is apparent for the decline of hen weights from December to February, 1942. After the latter date, the hens remained relatively heavy until June 5th. The hens autopsied from December through May were extremely fat. The accumulation of fat and the large increase in the ovary probably accounted in part for the gains exhibited by the hens in the spring. The weight of the ovary itself was not enough to account for the spring weight increases in the hens, because the ovary did not enlarge significantly until late March, sometime after the body weights had begun to increase. Although it is assumed that the prolonged laying of the confined hens eventually forced their weight decline in the summer, the decline was not marked until after the laying season when hot weather and the molt might have been predisposing factors. Laying began April 8 and continued until about June 15th.

If the weight curves are inspected for the late 1942 and early 1943 months, the trend will be observed to be quite dissimilar to that of a year before although the average weights were from the remaining birds of the same flock. Notably neither cocks nor hens attained their heaviest weights in December of their second winter, but did so in the following March. Furthermore, there appeared no tendency for the cocks to lose while the hens gained, as there was the previous year, but the two weight curves remained essentially parallel exhibiting more or less gradual gains from November to March. How this anomalous weight behavior can be reconciled with the previous winter's weights, for which there are so many clear conformities in wild species, is not apparent.

Because there were several uncontrolled differences between the pheasant flocks weighed for the two periods, valid explanations for the differential results perhaps are impossible. These differences were (1) feed: the ration was changed after June 15, 1942, but both rations were nutritively equivalent; (2) age: (3) weather: the winter of 1942–'43 had more snowfall and more days of extreme cold than the previous winter (4) numbers weighed: each point of the curve for the first winter's average weights represent a hundred more birds of each sex than the average weights of the second winter.

Organ measurements

The first significant weight change in the ovary occurred at an age of 306 days, in March (fig. 2). Then followed an extremely rapid increase in the ovarian weight until an average weight of 35.2 gm. was attained. This was noted in May when the last autopsy was made, so it is not certain that the 35.2 gm. average was the maximum size attained during the breeding season.

The increase in the ovary, although greater and more rapid than that of the testis, lags after the testis. Testicular increases were noted as early as February 16th when the cocks were 271 days old. At that time motile sperm were found in the testes, epididymides and vasa deferentia. Histological study of the preserved testes has revealed that, in some individuals, spermatogenic activity occurred as early as August and September when the cocks were only 94–109 days old (Kirkpatrick and Andrews, '44). Maximum weight of the testes was reached April 20th at 334 days with a definite decline occurring after that date. The regression parallels that which Bissonnette ('30) found in the male starling (Sturnus vulgaris) in which the testes undergo rapid regression in June, long before the highest summer temperatures. Dalke (in Bent, '32) gives the measurements of pheasant testes on May 1st as 16 × 30 and 22 × 35 mm. These pheasants were taken in the state of Michigan. For pen-reared pheasants the average measurements of six testes on

April 20th were 20 × 33 mm., and on May 18th the average for ten testes was 19 × 30 mm.

The increase in the size of the gonads was correlated with the body weight, positively in the females and negatively in the males (fig. 1). Riddle ('25) has noted that in pigeons a decrease in the thyroid is concomitant with spring and summer and with enlarged gonads at those seasons. This was barely suggested in pheasants by decreases in the thyroid weights from 285 to 334 days (fig. 3).

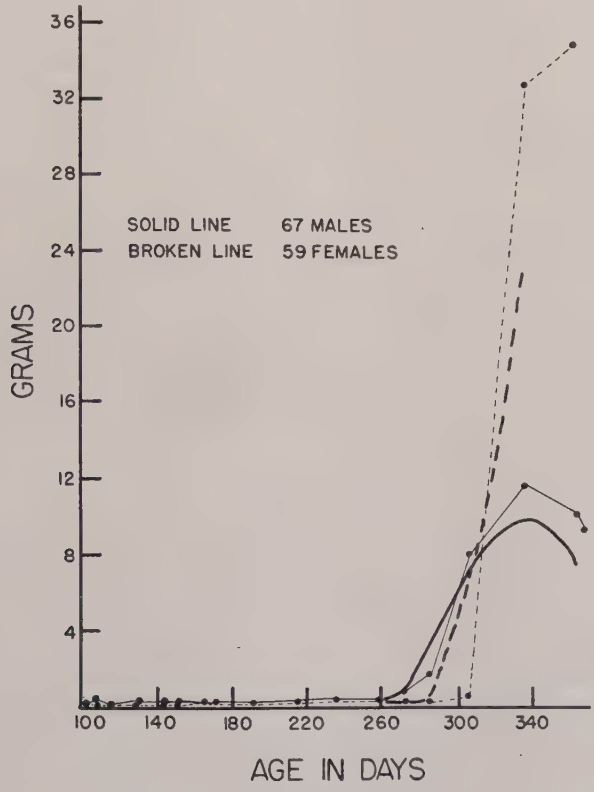

Fig. 2 Gonad weight in relation to age.[3]

The small size of the gonads up to 257 days covered the entire period of rapid growth and involution of the thymus (fig. 2, 6). During the same time, the maximum growth and nearly complete involution of the bursa took place (fig. 16). Riddle ('28) reported for ring doves that rapid growth of the gonads coincides with the beginning of thymus and bursa involution. In turkey hens Latimer and Rosenbaum ('26) found

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[3] Heavy lines in figs. 2–16 are based on moving averages.

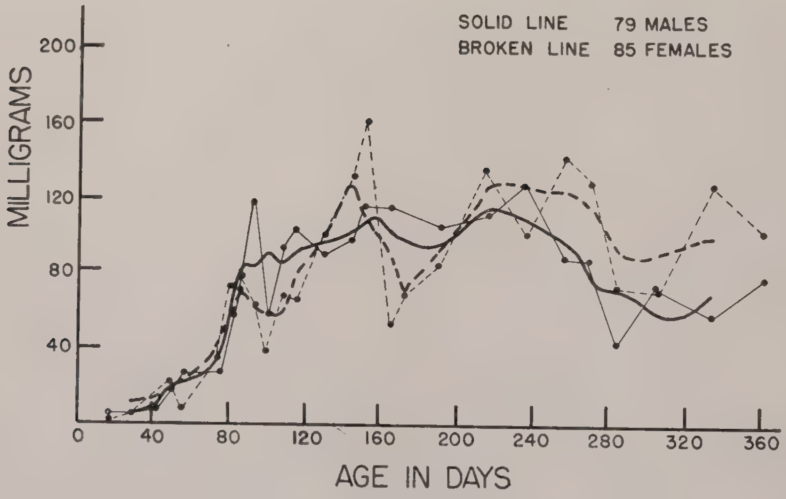

Fig. 3 Thyroid weight in relation to age.

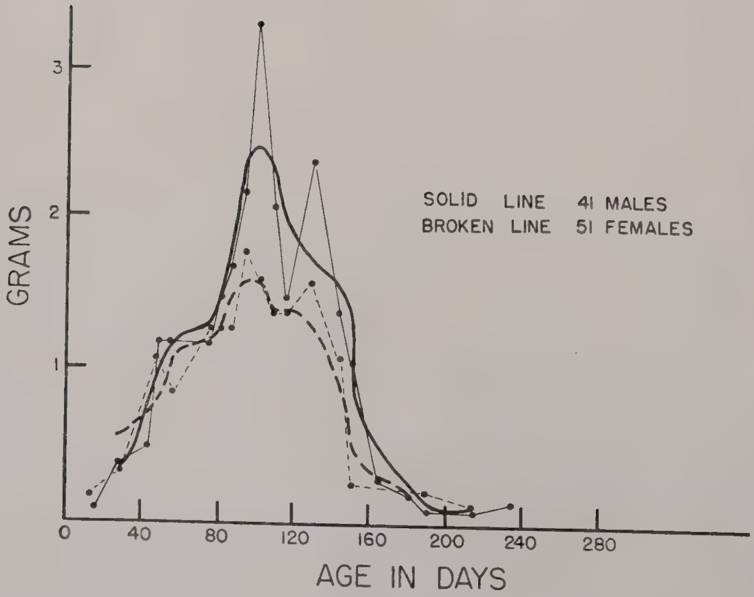

Fig. 4 Thymus weight in relation to age.

the heaviest thymus about a month before laying (spring) but there was a rapid decrease after this maximum. In pheasants, however, the thymus was completely involuted, i. e., it could not be discovered by gross examination, before the increase of the gonads was noted. Involution of the bursa likewise began several months in advance of gonad enlargement (fig. 16), and was simultaneous with initiation of thymus involution. There is some evidence that the thymus and bursa involution may be under the control of sex hormones, since some spermatogenesis has been noted coincident with the beginning of thymus and bursa involution (Kirkpatrick and Andrews, '44).

The thymus and bursa reached their maximum size between 100 and 130 days at the time of most rapid body growth. Likewise, during this period of rapid body growth, the pancreas and gizzard of both sexes are at their maxima, as well as the male spleen and kidney (figs. 7, 9, 11, 12). The maximum lengths of the intestine and caeca of both sexes occur between 80 and 120 days (figs. 14, 15). Mitchell, Card, and Hamilton ('26) reported that the digestive organs of White Rock chickens reached their largest size before the mature body size was attained. Apparently those organs concerned with the digestion and assimilation of food respond with maximum growth to the energy demands of the rapidly growing body. Measurements of the organs of pheasants, indicate that after the adult body size is reached, some of the organs decrease in size.

Riddle and Fisher ('25) found an enlargement of the thyroid in pigeons during the fall and winter. There is no evidence of this in pheasants (fig. 3). The most remarkable fact about the pheasant thyroid weights is a significant sex difference in average weights (table 1). After the females reach adult size, their thyroid weights continue to exceed those of the male.

The adrenal weight increased more or less gradually up to a maximum at 285 days when there was a plateau established during the breeding season (fig. 4). The largest size of the adrenals was correlated with weight losses in cocks, suggesting intensified adrenal activity during the breeding period. The pituitary reached its maximum size at 120 days in both sexes (fig. 5), and this was correlated with the period of rapid growth. At this time the gland probably hypertrophied as it produced relatively large amounts of the growth promoting substance. As soon as the body was grown to adult size, the pituitary varied little in weight, although the male gland was heavier than that of the female.

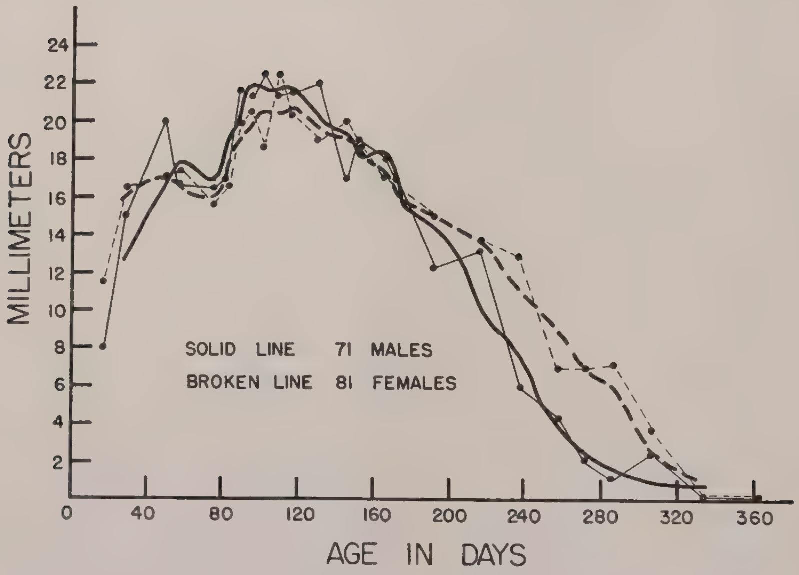

Fig. 5 Bursa depth in relation to age.

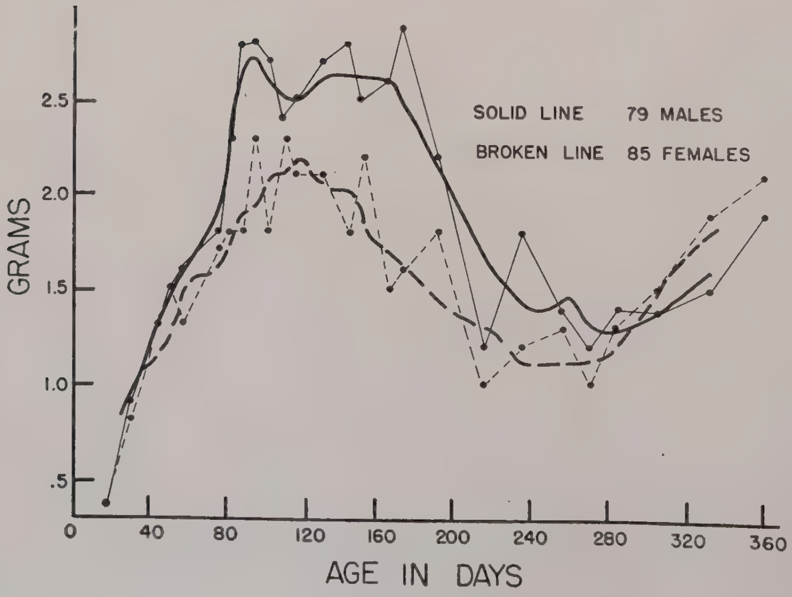

Fig. 6 Pancreas weight in relation to age.

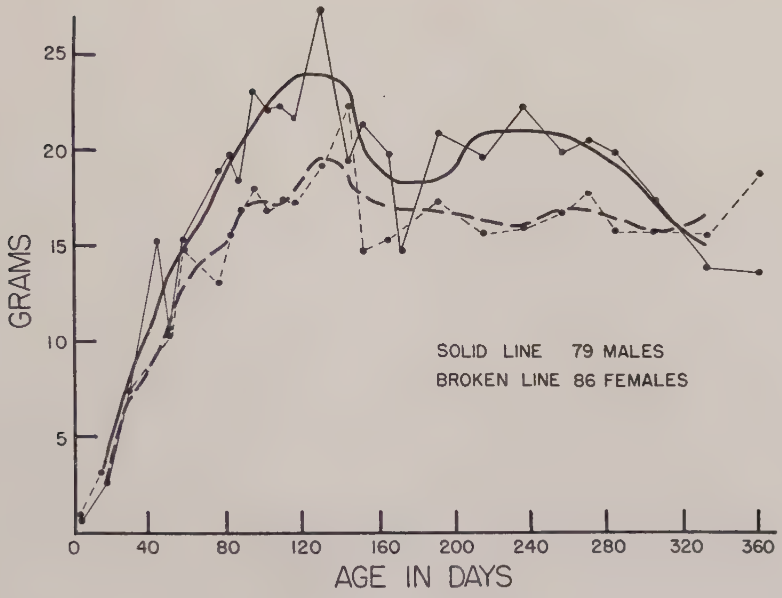

Fig. 7 Gizzard weight in relation to age.

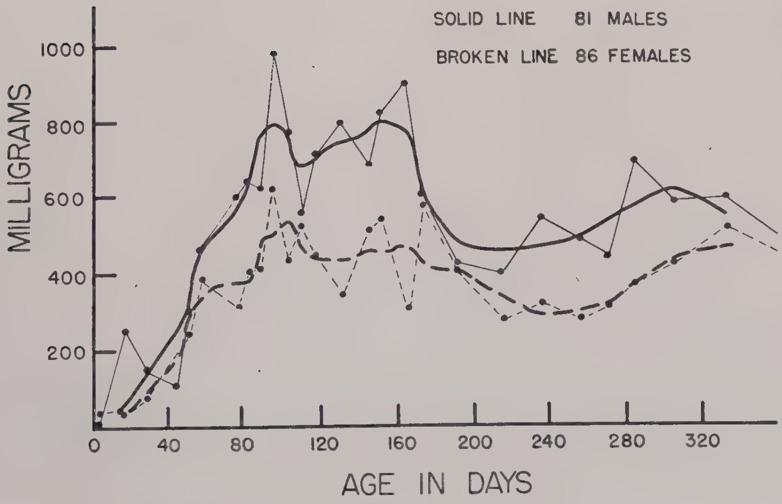

Fig. 8 Spleen weight in relation to age.

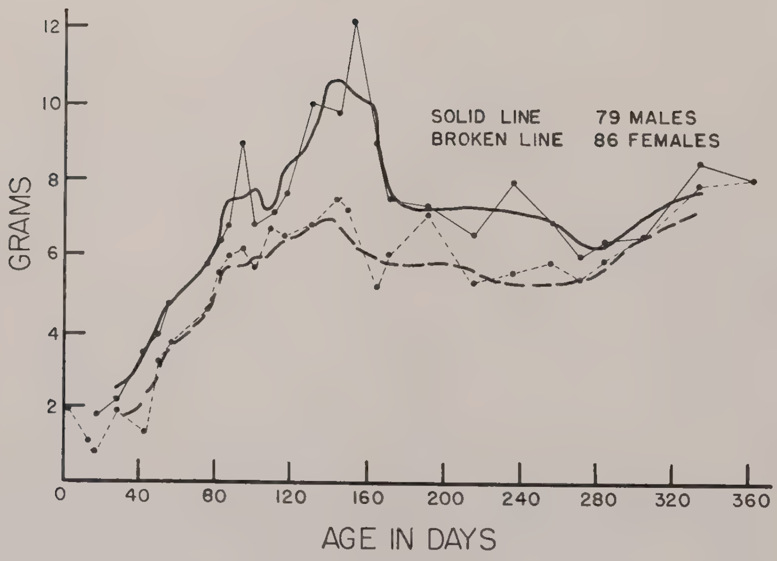

Fig. 9 Kidney weight in relation to age.

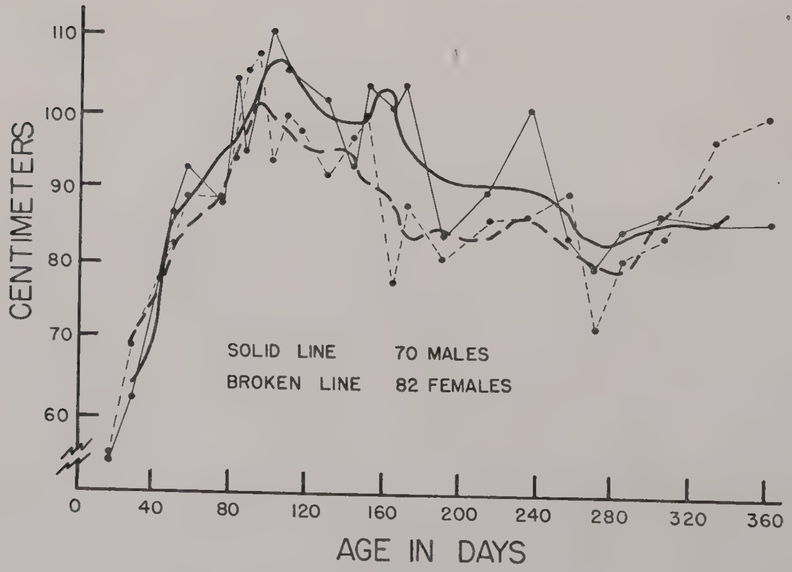

Fig. 10 Intestine length in relation to age.

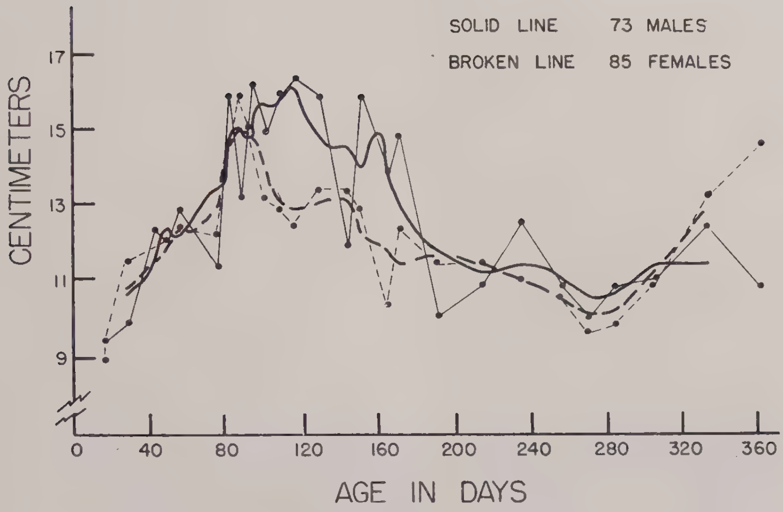

Fig. 11 Caeca length in relation to age.

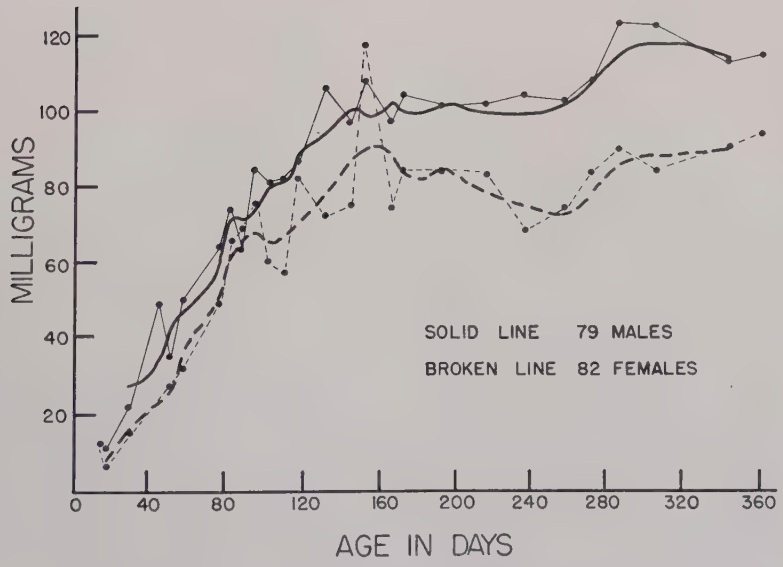

Fig. 12 Adrenal weight in relation to age.

Besides the maxima of the male and female pancreas reached before adulthood, there was also an increase in the weight of the pancreas from 344 to 362 days. This increase was highly significant in the males and significant in females when a comparison was made with the weights of the glands taken at 285 and 306 days. During both of these periods the cocks lost weight rapidly and the females began to lose weight at 341 days (fig. 1).

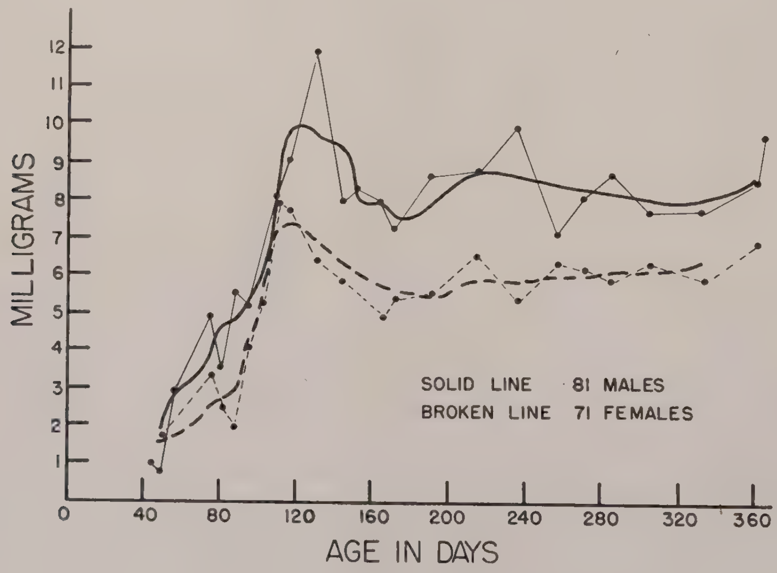

Fig. 13 Pituitary weight in relation to age.

There was an observed but not a significant increase in the male liver from 130 to 172 days, and a highly significant increase in the male spleen from 87 to 172 days. No such increases were observed in the corresponding female organs although the weight of the female liver tends to increase gradually with age (figs. 8, 11). Riddle ('28 b) found that the livers and spleens of female ring doves were heavier than those of the males. This is not true in pheasants, although there is a considerable sex difference in body weights in pheasants which is not the case in doves. In the same paper Riddle also stated that the livers and spleens are larger during spring and summer than during fall and winter. Apparently the reverse is true in pheasants on the basis of present data.

The weight of the heart gradually increases with age in both sexes (fig. 10).

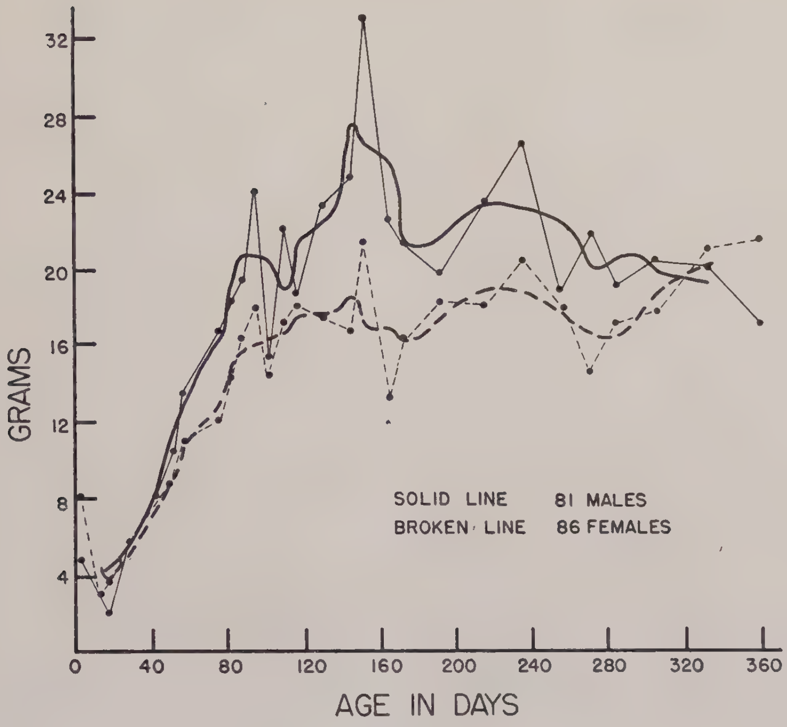

Fig. 14 Liver weight in relation to age.

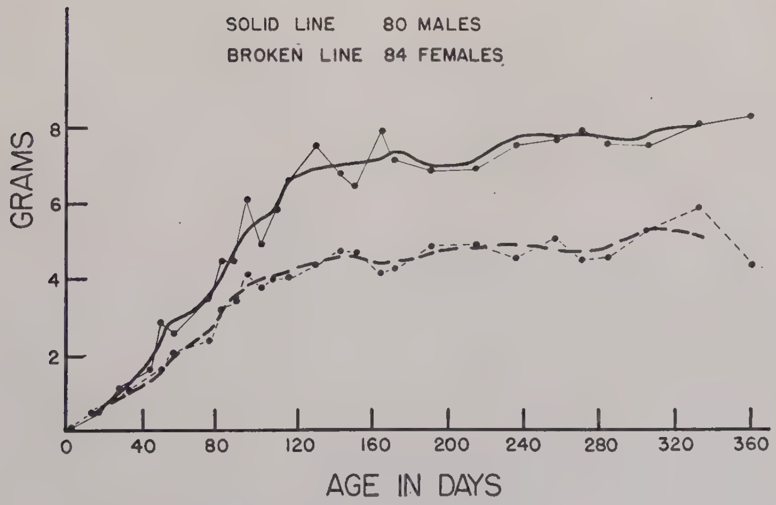

Fig. 15 Heart weight in relation to age.

A highly significant increase in the male kidney occurred between 116 and 172 days, but no such increase was noted in the female organ (fig. 12). After 170 days the average kidney weights tend to remain uniform.

There was an observed but insignificant increase in the weight of the male lungs between 94 and 172 days. Otherwise the lung weights of both sexes tended to remain stationary after 180 days.

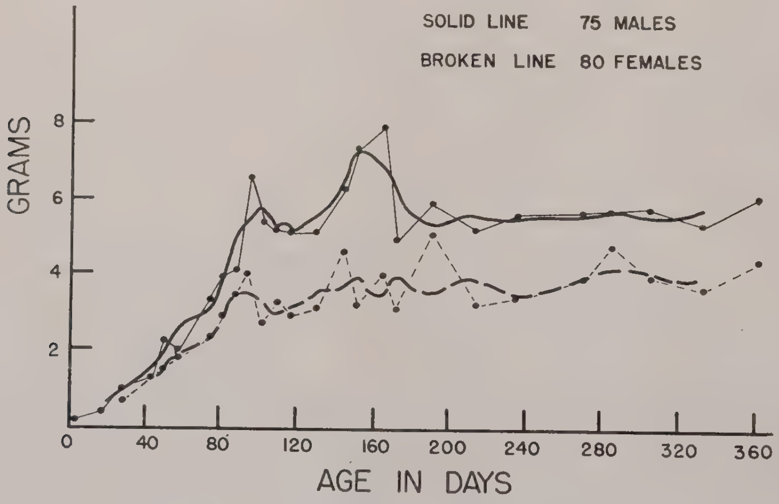

Fig. 16 Lung weight in relation to age.

SUMMARY

A growth curve for a flock of artificially reared ring-necked pheasants was based upon live weights taken at approximately 5-week intervals from June 3, 1941, to March 22, 1943. Growth of the organs were studied by autopsying 177 pheasants to collect organ weights and measurements.

The period of most rapid body growth was from 42 to 138 days of age and was correlated with increases in the thymus, pancreas, intestine, and caeca. The bursa also reached its maximum depth during this period. The heaviest body weights were reached in winter at 210 days and the lightest weights were recorded in the summer, corresponding with observations on some wild species. There was no evidence of seasonal fluctuations of body weight being positively correlated with changes in thyroid weights.

In their first year, cocks began to lose weight before the breeding season, which commenced about April 1st, reaching their lowest weights in June. Hens in their first year did not lose weight until the breeding season began, and did not lose appreciably until the laying season was about over. Hens reached their lowest weight in August. The weight behavior of pheasants in their second year is dissimilar from that of the first year in that the maximum weights are attained not in winter but in the spring in both sexes. Some possible reasons for this dissimilarity are differences in food, age, weather, and numbers of birds weighed.

In its seasonal development, the ovary lagged behind the testis more than a month although the growth of the ovary was more rapid. The hypertrophy of the gonads did not occur until the thymus had completely involuted and the bursa nearly so.

There was evidence that the organs connected with digestion and assimilation of food are at their maxima during the period of most rapid body growth. No significant fluctuations were found in the weights of the pituitary, adrenal, heart, lungs, liver, and gizzard of either sex.

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			H. H. Wilder—5 years
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1933–1935.	L. R. Cleveland	F. L. Hisaw	Franz Schrader
1934–1936.	Charles Zeleny	J. F. Daniel	J. S. Nicholas
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1941–1943.	E. G. Butler	W. N. Hess	W. A. Kepner

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1890—Boston
1891—Philadelphia
1892—Princeton
1893—New Haven
1894—Baltimore
1895—Philadelphia
1896—Boston
1897—Ithaca
1898—New York
1899—New Haven
1900—Baltimore
1901—Chicago
1902—Washington

Central Naturalists

1899—Chicago
1900—Chicago

Society of American Zoologists

1901—Chicago
1902—Washington

American Society of Zoologists

EASTERN BRANCH

1903—Philadelphia
1904—Philadelphia
1906—New York
1907—New Haven
1909—Boston
1910—Ithaca

JOINT MEETINGS

1905—Ann Arbor
1908—Baltimore
1911—Princeton
1912—Cleveland
1913—Philadelphia

CENTRAL BRANCH

1903—St. Louis
1905—(Mch.) Chicago
1907—(Mch.) Madison
1907—Chicago
1910—(Apr.) Iowa City
1910—Minneapolis
1912—(Apr.) Urbana

MEETING PLACES

1914—Philadelphia
1915—Columbus
1916—New York
1917—Minneapolis
1918—Baltimore
1919—St. Louis
1920—Chicago
1921—Toronto
1922—Boston
1923—Cincinnati
1924—Washington
1925—New Haven
1926—Philadelphia
1927—Nashville
1928—New York
1929—Des Moines
1930—Cleveland
1931—New Orleans
1932—Atlantic City
1933—Boston
1934—Pittsburgh
1935—Princeton
1936—Atlantic City
1937—Indianapolis
1938—Richmond
1939—Columbus
1940—Philadelphia
1941—Dallas
1942—New York (cancelled)
1943—No meeting held

AMERICAN SOCIETY OF ZOOLOGISTS

CONSTITUTION

Article I

NAME AND OBJECT

Section 1. The Society shall be called the "American Society of Zoologists."

Sec. 2. The object of the Society shall be the association of workers in the field of zoology for the presentation and discussion of new or important facts and problems in that science and for the adoption of such measures as shall tend to the advancement of zoological science.

Article II

MEMBERSHIP

Section 1. The membership of the Society shall consist of two classes:

a. Associate membership open to all actively engaged in the field of zoology who have had training in zoology equivalent to that required for the doctorate degree.

b. Active membership open to those who hold the doctor's degree in zoology or who have done work equivalent thereto, and who, in addition to the usual requirements for this degree, have published the results of substantial zoölogical research.

Sec. 2. Election to membership in the Society shall be upon recommendation of the Executive Committee.

Sec. 3. Associate members shall not hold office or vote, but may present papers before the Society without introduction. Associate members shall receive all literature issued by the Society, including the proceedings of the Society, and shall have the same privileges as active members in journal subscriptions.

Sec. 4. Associate members may be elected to active membership in the usual way when the research requirements of active membership have been met.

Article III

OFFICERS

Section 1. The officers of the Society shall be a President, a Vice-President, a Secretary, a Treasurer, and the members at large of the Executive Committee.

Sec. 2. The Executive Committee shall consist of the President, the Vice-President, the Secretary, the Treasurer, and five members elected from the Society at large. Of these five members, one shall be elected each year to serve five years. If any member at large shall be elected to any other office, a member at large shall be elected at once to serve the remainder of his term.

Sec. 3. These officers shall be elected by ballot at the annual meeting of the Society and their official terms shall commence with the close of the annual meeting, except that the Secretary and the Treasurer shall be elected triennially and shall serve for three years.

Sec. 4. The officers named in Section 1 shall discharge the duties usually assigned to their respective offices. (See by-laws.)

Sec. 5. Vacancies in the board of officers, occurring from any cause, may be filled by election by ballot at any meeting of the Society. A vacancy in either the Secretaryship or the Treasurership occurring in the interval of the meetings of the Society may be filled, until the next annual meeting, by appointment by the Executive Committee.

Sec. 6. At the annual meeting the President shall name a nominating committee consisting of three active members. It shall be the duty of this committee to nominate officers of the Society, including the permanent representatives which the Society is asked to name to various boards and councils. This committee shall make its nominations to the Secretary at least four months before the next annual meeting. Additional nominations for any office may be made in writing to the Secretary by any five members at any time previous to balloting.

ARTICLE IV

MEETINGS OF THE SOCIETY

Section 1. Unless previously determined by the Society, the time and place of the annual meeting shall be determined by the Executive Committee. Special meetings may be called and arranged for by the Executive Committee. Notices of such meetings shall be mailed to all members of the Society at least two weeks before the date set for the meeting.

Sec. 2. Sections of the Society may be organized in any locality by not less than ten members, for the purpose of holding meetings for the presentation of scientific papers. Such sections shall have the right to elect their own officers and also associate members; provided, however, that associate membership in any section shall not confer membership in the Society.

ARTICLE V

QUORUM

Twenty-five members shall constitute a quorum of the Society and four a quorum of the Executive Committee.

ARTICLE VI

CHANGES IN THE CONSTITUTION

Amendments to this Constitution may be adopted at any meeting of the Society upon approval of two-thirds of the members voting, subject to the following conditions:

a. The proposed amendment must be in writing and signed by at least five members of the Society.

b. This signed proposal must be in the hands of the Secretary at least one month before the meeting of the Society at which it is to be considered.

c. The Secretary shall mail copies of the proposed amendment to the members of the Society at least two weeks before the meeting.

d. Members unable to attend may submit their votes in writing to the Secretary.

BY-LAWS

ARTICLE I

DUES

Section 1. The annual dues for active and associate members, unless remitted or changed by the vote of the Society, shall be two dollars.

Any member in good standing, having paid annual dues to the Society for not less than twenty-five years, who shall change his professional status, may apply to the Executive Committee for the remission of further dues. Applicants approved by the Executive Committee shall be exempt from further payment of dues, but such members shall be entitled to all of the privileges of membership formerly enjoyed.

Sec. 2. Any member in arrears of dues for two years should be dropped by the Executive Committee. Upon payment of arrearage he shall be reinstated.

ARTICLE II

PRESIDENT

Section 1. The President shall preside at scientific sessions and at the business meetings.

Sec. 2. He shall also appoint the committees prescribed by the constitution and by-laws.

ARTICLE III

VICE-PRESIDENT

Section 1. The Vice-President shall preside at sessions designated by the President.

Sec. 2. He shall also assume the duties of the President in the latter's absence.

ARTICLE IV

SECRETARY

Section 1. The Secretary shall keep the records of the Society.

Sec. 2. He shall be responsible for all arrangements for the meetings, including the appointment of local committees.

Sec. 3. Whenever the proper officers of a number of related societies shall have a conference covering matters of mutual interest to the several societies, he shall act as the delegate or representative of this Society.

Sec. 4. He shall make such purchases and employ such assistance as will, in his judgment, expedite the business of the Society, and

Sec. 5. He shall be reimbursed out of the funds of the Society for expenses incurred in attending meetings of the Society.

Article V

TREASURER

Section 1. The Treasurer shall be in charge of the funds of the Society.

Sec. 2. At the annual business meeting of the Society he shall present a statement to date of the funds of the Society.

Sec. 3. He shall make such purchases and employ such assistance as will, in his judgment, expedite the business of the Society.

Article VI

AUDITING COMMITTEE

The President shall annually appoint an auditing committee of two, who shall audit and report upon the financial record and statement of the Treasurer at the meeting for which they were appointed.

Article VII

PROGRAM RULES

In matters relating to programs for annual meetings, the following rules shall be observed:

Section 1. Titles and abstracts of papers to be presented by any method at the annual meeting must be sent to the Secretary in duplicate before the final date set by him. The length, form, and arrangement of the abstracts must comply with the requests of the Secretary in order to insure prompt publication by The Wistar Institute. The titles and abstracts of papers which do not conform to such requests or papers which are received late may be presented by title only.

Sec. 2. Titles shall be listed in groups according to subject matter, the groups to be determined by the Secretary.

Sec. 3. Whenever conditions require, the Secretary shall schedule two or more groups for the same hour and arrange the program to bring together papers on subjects of more general interest for meetings of the whole Society.

Sec. 4. Each member may have not more than fifteen minutes of the time of the Society at the annual meeting. This time may be used by him to present one or more papers personally or to introduce papers of non-members.

Sec. 5. All papers not read when called for as listed shall be placed at the end of the group list, and if not read when called for the second time, shall be read by title only.

Sec. 6. The titles of 'introduced' papers may be listed in the groups after the titles of papers to be read by members.

PROCEEDINGS OF THE AMERICAN SOCIETY OF ZOOLOGISTS

ANNUAL MEETING

In view of the prevailing heavy demands on our war-burdened public transportation facilities and in compliance with a renewed request from the Office of Defense Transportation for the cancellation of conventions and other similar travel-stimulating events, the Executive Committee regretfully voted to cancel the annual meeting for 1943. However, in order to maintain some continuity in the absence of an annual meeting, the Committee decided to continue all feasible Society activities and voted in favor of the collection and printing of abstracts as usual. The customary call for papers was therefore issued early in the fall and all titles and abstracts received were assembled, printed, and distributed to members of the Society as in former years.

The total number of papers submitted was 101. However, two of these were recalled at the last minute so that actually there were only ninety-nine abstracts printed. This represents a considerable reduction in number of papers submitted when compared with the preceding year. It should be recorded that some papers, the number probably being larger than is realized, were withheld in the absence of a regular meeting because the authors preferred to present their material in person.

The Vice-President of Section F of the American Association for the Advancement of Science was Dr. Carl R. Moore who prepared the address normally given at the Annual Dinner of the American Society of Zoologists. This address was published in the American Naturalist (vol. 78, no. 775, pp. 97–130) under the title "Gonad Hormones and Sex Differentiation".

BUSINESS TRANSACTIONS

This is the second consecutive year in which the Annual Meeting of the Society could not be held and special arrangements were therefore necessary for the transaction of Society business. It will be recalled that the Society Referendum of January 1943 granted the Executive Committee authority to conduct the routine business of the Society during the interim. Because of the great distances separating the members of the Executive Committee and to curtail excessive travel, it was decided as in the preceding year, to conduct the routine business on the agenda by mail. The following business was transacted:

1. *The minutes of last year's business.* The minutes of last year's business were published in the June 1943 supplement of The Anatomical Record and distributed to all members of the Society.

The Executive Committee voted unanimous approval of the minutes as printed.

2. *Memorial resolutions.* The Secretary reported that during the past year the Society had suffered the loss by death of six active members. These were Edgar Allen, Bert Cunningham, Roscoe Raymond Hyde, Richard Anthony Muttkowski, Francis Huntington Swett, and Ivon Roy Taylor. The following resolutions were prepared.

EDGAR ALLEN

The sudden death of Edgar Allen on February 3, 1943 took from our society a distinguished member who was an eminent anatomist and an international authority on the physiology of sex and reproduction.

Professor Allen was born at Canyon City, Colorado, on May 2, 1892 and his family moved soon after to Providence, R. I. He acquired a love of the sea in his early youth and became an expert in sailing. His knowledge of the waters of Narragansett Bay and Long Island Sound, his sense of duty and his zeal for action prompted him to volunteer for service in the Coast Guard Auxiliary soon after the present war began. He was stricken while on patrol duty as junior commander and operations officer of a unit of the flotilla.

He completed his undergraduate study at Brown University in 1915, received an M.A. in 1916 and a Ph.D. in 1921. His graduate work was interrupted by the first World War during which he served first as a volunteer in the Brown University Ambulance Unit, and later as a 2nd lieutenant in the Sanitary Corps. His first academic position after the close of the war was that of Instructor and Associate in Anatomy at Washington University School of Medicine in St. Louis. He was appointed Professor and Chairman of the Department of Anatomy in the University of Missouri Medical School in 1923 and later served successively as Assistant Dean, Acting Dean, and Dean. In 1933 he was called to Yale University School of Medicine as Professor of Anatomy and Chairman of the Department of Anatomy.

Professor Allen's first scientific contribution dealt with oogenesis in the mammalian ovary. He discovered that ova were formed after birth and even during sexual maturity; a fact at variance with the view then generally accepted. While studying oogenesis in the mouse, he noticed the close correlation between the formation and growth of follicles and corpora lutea in the ovaries and the morphological modifications in the uterus and vagina during the oestrous cycle. These observations lead him to surmise that the follicles of the ovary secreted a hormone which brought about the cyclic changes seen in the female reproductive tract.

Allen seemed happiest when working with a group of collaborators. His youthful bouyance, keen imagination and personal vigor promoted good fellowship among those with whom he worked. He enjoyed open discussions but avoided debates. His frank criticism and advice were sought, especially by his young colleagues, and quick recognition of good work by others was given with honest enthusiasm. These qualities served him well in the many cooperative projects in which he took part.

Allen collaborated with his friend Professor E. A. Doisy on the problem of isolating the ''ovarian follicular hormone'' and determining its general chemical characteristics. In cooperation with Dr. J. P. Pratt at the Henry Ford Hospital in Detroit, he obtained the first living ova from the oviducts of women, thus contributing useful information concerning the time of ovulation in the human menstrual cycle. They also performed the first clinical experiments with the ''ovarian follicular hormone'', which was an application of his earlier research on the monkey.

During the few years he was at Yale he gathered about him a group of enthusiastic and able young investigators of whom he was very proud. Their researches dealt with many aspects of endocrinology and their published reports were numerous and diverse. For many years, Allen was interested in the growth-stimulating effects of oestrogens which led him naturally into an extensive study of the carcinogenic action of steroid hormones. He was a contributor, and at the same time took chief editorial responsibility, in writing the first and second editions of ''Sex and Internal Secretions''. He will also be remembered by his colleagues for the many stimulating and for the most part unpublished papers which he gave on invitation before selected groups and learned societies.

Allen's reputation was international and he received many recognitions. He was an active member in a number of scientific organizations; was President of the Association for the Study of Internal Secretions in 1941 and at the time of his death was President of the American Association of Anatomists. The degree of Doctor of Science was conferred upon him by Brown University and Washington University. He was enrolled in the Legion of Honor of France in 1937 and was awarded the Baly Medal of the Royal College of Physicians of London in 1941.

The untimely death of one so able is an inestimable loss. His accomplishments will remain as an enduring cornerstone in the great edifice of scientific endeavor, and his influence will live on among his colleagues and in succeeding generations of scholars.

FREDERICK L. HISAW

BERT CUNNINGHAM

In the death of Dr. Bert Cunningham on September 27, 1943 the American Society of Zoologists lost one of its worthy and productive members.

Dr. Cunningham was born in McLean County, Illinois on June 3, 1883, so he lived a little more than 60 years. He received his B.S. and M.S. degrees from Illinois Wesleyan University in 1908 and 1909, an M.A. from Trinity College in 1916, and a Ph.D. from the University of Wisconsin in 1920. From 1909 to 1911 he served as Head of the Department of Science in Missouri Wesleyan University. For 6 years (1911–1917) he taught in the high schools of North Carolina. He was Head of the Department of Biology of Trinity College for 8 years (1917–1925) and when that institution became embodied in Duke University he continued as Professor of Biology until the time of his death.

His early work was concerned with marine and freshwater algae, under the influence of his predecessor at Trinity College, Dr. J. J. Wolfe. Later he became interested in embryological problems and wrote his doctorate thesis on the embryology of turtles. For several years he did research on the effect of increased pressure on the development of turtle and fowl eggs. With the rise of endocrinology Dr. Cunningham became an enthusiastic supporter of that science. He spent a semester of study in the Harvard Medical School in 1929, and thereafter devoted himself to research in endocrinology, with special reference to embryology. At the time of his death he was actively engaged in the assay of prolactin from the blood of alligators and marine turtles. Dr. Cunningham spent considerable time in research at the Biological Laboratory of the United States Fish and Wild Life Service at Beaufort, N. C. He also spent several summers at the Cold Spring Harbor Laboratory on Long Island. There he gave a series of lectures on endocrinology and supervised problems in that field.

For many years Dr. Cunningham was a leading member of the North Carolina Academy of Science. He was President in 1927, served as Secretary three times (1917, 1921–1926, 1940–1943), and was holding that office when he died. He did much to create interest in scientific matters among high school teachers, developed sets of lantern slides for loans to public schools, and in many other ways helped make the academy a success.

A. S. PEARSE

ROSCOE RAYMOND HYDE

The death of Roscoe Raymond Hyde on September 15, 1943 at the age of 59 came as a great shock to all who knew him. Death came to him very suddenly when he seemed well on the road to recovery from a serious operation.

Dr. Hyde was a native of Indiana. His first collegiate training was in the Indiana State Normal School, from which he received the A.B. degree in 1908. After a year of further study at the University of Indiana he returned to the State Normal School as a member of the faculty. He served this institution from 1909 to 1919 first as Assistant Professor and later as Professor and Head of the Department of Zoology and Physiology. During this period he was given leave of absence to continue his graduate studies at Columbia University and was granted the Ph.D. degree from this institution in 1915. In 1919 he accepted the position of Associate in Immunology in the School of Hygiene and Public Health of The Johns Hopkins University. He served on the staff of this institution up to the time of his death. In 1928 he was placed in charge of the newly organized Department of Filterable Viruses. Then in 1932 he became Professor of Immunology and combined in his department both the subjects of immunology and filterable viruses.

Dr. Hyde was a fine teacher. His ready wit and enthusiasm made his lectures very stimulating to the students. He was especially interested in the training of research workers and a number of able students completed the doctorate under his direction. He was easy to approach and took a friendly, personal interest in all his students.

Dr. Hyde was primarily interested in research. He was original in his thinking and threw himself into the problems he was investigating with diligence and enthusiasm. He was trained as an experimental biologist in genetics under Dr. T. H. Morgan. His early researches in immunology also involved a genetic problem since he discovered and maintained over a period of 14 years a colony of complement deficient guinea pigs. His studies on this colony added greatly to the knowledge of the nature and relations of the complement in serum. He rediscovered and clarified the principles and underlying nature of the heterophyle-isophyle antigen-antibody complex. These researches stimulated a great deal of fundamental work in the field of immunology. After 1928 Dr. Hyde's researches dealt with the nature and characteristics of the filterable viruses. His numerous papers and those of his students during this period have been important contributions to the knowledge of the viruses of infectious myxomytoses, rabies, influenza and other diseases. All through his work he showed a fundamental interest in the problems of the origin and nature of living things.

His friends will greatly miss Dr. Hyde. His originality and wit made him a delightful companion. He could even lighten the gloom of oral examinations by the unusual and humorous way he developed his questions to the candidates. His personality and work will be perpetuated not only in his scientific publications, but also in the impress that he made over the years on the numerous students who had the good fortune to work with him in the class room and in the laboratory.

W. W. Cort

RICHARD A. MUTTKOWSKI

Richard A. Muttkowski was born in Milwaukee, Wisconsin, on March 4, 1887. He received his early training in zoology while working as an Assistant in the Milwaukee Public Museum, 1906–1912. Here under Charles T. Brues and S. Graenicher he worked with insects and became especially interested in the Odonata. While in the Milwaukee Museum he published his two longest and best known works: Review of the Dragon-Flies of Wisconsin, 1908, and Catalogue of the Odonata of North America, 1910. He received an A.B. from St. Lawrence College, 1904, and again in 1913 from the University of Wisconsin where, in 1916, he was also granted the degree of Doctor of Philosophy. His published thesis was: The Fauna of Lake Mendota — a qualitative and quantitative survey with special reference to the insects, 1918.

He taught in the zoological departments of the University of Missouri, Kansas State College, and the University of Idaho, finally going to the University of Detroit, in 1925, where he was Professor of Biology and Chairman until his death on April 15, 1943. Dr. Muttkowski was very much interested in music and while at the University of Wisconsin he was organist in St. Paul's University Chapel.

M. F. Guyer

FRANCIS HUNTINGTON SWETT

Francis Huntington Swett, Professor of Anatomy in the School of Medicine of Duke University, and Secretary of the American Association of Anatomists, died suddenly on February 10, 1943. His untimely death was wholly unexpected, and a great shock to his colleagues and an unusual number of friends everywhere. The University and School suffer greatly in the loss of a man who was a member of the Medical Faculty from its inception, its first Professor of Anatomy, and who in recent years had gradually assumed more and more of its administrative burdens.

Frank Swett was born at Norway, Maine on November 13, 1893. He received his undergraduate training at Bates College, in near-by Lewiston, from which he graduated with honors in 1916. His chosen field was zoology, and in the following year he began his graduate studies at Brown University. Here he took his Master's degree in 1917, as a student under Mead and Walter, by whom he was greatly influenced. The following year was spent at Tufts, where he served as Instructor in premedical subjects, at the end of which his academic training was interrupted by military service. Assigned to the Army Medical Corps, he was sent after a time to the Army Neuro-surgical Laboratory at The Johns Hopkins Medical School, in Baltimore — a fortunate event that was to have an immense influence on his later career. Here his duties brought him under the supervision of Captain Lewis H. Weed, and thus came about an association which led to his return to The Johns Hopkins University a few years later as Instructor in Anatomy under Dr. Weed. Here also he met his future wife — Elizabeth Glenn. At the end of the war Swett resumed his graduate studies at Yale under the direction of Harrison. From 1919 to 1922 he served as Assistant in both Zoology and Anatomy, and received his degree as Doctor of Philosophy in the latter year. Returning to Baltimore he was Instructor in Anatomy from 1922 to 1924, and Associate for the academic year 1924–1925. His marriage occurred during this interval, and henceforth his wife was to share his life in far more than the usual degree; for her training, interests and personal qualities fitted her most admirably to be his other self in all their future activities and relations. In 1925 he transferred to Vanderbilt University, holding the rank of Associate Professor of Anatomy, with supervision of the instruction of gross anatomy, until 1930.

When, in the latter year, he was appointed to the Chair of Anatomy at Duke he well appreciated the unusual opportunity and responsibility that falls to the organizer of a department in a new school. For better or worse, and for a long time to come, its character, objectives and standards will necessarily derive more from the ideas and ideals of one man than can ever be so under other circumstances. Influenced strongly in his own student days by a succession of great teachers, he had long since developed very positive views as to the functions and responsibilities of a teaching department. These he proceeded to carry out with assurance, choosing as his helpers enthusiastic young men, qualified not merely to teach but to instill confidence and enthusiasm. The welfare and progress of the student was to be the primary concern of all, and he set the example in person. In this department esprit de corps was found to a remarkable degree among both staff and students. In complete contrast to the principle of close-knit cooperation in the teaching organization was his conviction with regard to research in the department. His staff was chosen to represent as many different interests as possible, and each man was encouraged to pursue his own problems with entire freedom; this with a view to encouraging individuality and zeal, while exposing students and staff alike to that variety of appeals that spices anatomy no less than other subjects. The success which he had was due in no small part to the splendid cooperation which he drew from everyone; and the department, consciously or not, will show for a long time the influence of his personality.

Swett's investigative work, initiated as a student under Harrison, was concerned almost entirely with problems of the vertebrate limb: its early representation in the limb disc, determinative processes, and in particular symmetry relations and the reversal of asymmetry. With respect to the latter he found in the limb an opportunity to attack on a local scale a problem which had previously baffled him (and many another) when, in the form of situs inversus viscerum, it involves the whole organism. His earlier experiments dealt with the distribution of limb-forming potency in the arbitrarily defined limb disc, analyzed in terms of quadrants; later he studied the phenomena of regeneration and reduplication, especially the symmetry relations of reduplicating members. Eventually he was driven to an investigation of the part played by the surrounding girdle region in the origin of axiation and asymmetry; demonstrating that earlier results, especially where time relations are involved, are conditional upon the status quo in the girdle zone. After an incredible amount of exact, and exacting, experimentation he fully recognized that the main problem (once termed by Harrison a ''Frankenstein'') remained unsolved in its essentials; and he was not one to confuse repeated demonstration of rules and principles with the solution of underlying causes. By steadily narrowing and defining the conditions under which the accepted rules and principles hold, he made a great contribution to future progress in a complex field.

But for a great number of people to whom Frank Swett was first of all a friend and confidant, conventional forms of appraisal poorly convey the qualities which they valued most. They found in him a rare infusion of simple candor, serenity, and a cordiality or inward warmth that escapes ordinary words. In his contacts he was direct and sincere in every word, unsparing of his time and personal efforts, unassuming almost to a fault. By his associates, friends and many a class of students he will be remembered with affection and a distressing sense of personal loss.

ROBERT K. BURNS

IVON ROY TAYLOR

Dr. Ivon Roy Taylor, Associate Professor of Physiology in Brown University died suddenly and unexpectedly of coronary thrombosis on September 20, at Providence, Rhode Island.

Dr. Taylor was born at Prince Albert, Saskatchewan, Canada, November 14, 1897. He did his undergraduate work at Reed College, Oregon, receiving his A.B. in 1922. He did graduate work at the University of Oregon, receiving the M.S. in 1924, and then at the University of Pennsylvania, under the direction of J. H. Bodine, received the Ph.D. degree in 1927. During 1924–1927, he was Instructor at the University of Pennsylvania. In 1927 he became Instructor in Physiology at Brown. He was promoted to Assistant Professor in 1930 and to Associate Professor in 1939. During the summers of 1930 to 1936 he served as Instructor in Physiology at the laboratory of the Long Island Biological Association at Cold Spring Harbor.

His publications include part authorship, (with P. H. Mitchell) of a laboratory manual of general physiology, and numerous papers on insect physiology, particularly the physiology of metamorphosis of the bee moth and the electrical phenomena accompanying changes in illumination of the insect eye.

He was personally of a quiet and unassuming nature. An excellent teacher of undergraduates, he has also had a devoted group of graduate students. He had an excellent command of physical apparatus and methods, and published his results only after the most careful and repeated checking. He was generous and patient in helping others as his students and colleagues will testify. Those of us who have been close to him feel that in his passing we have lost a valued friend and biological science an important contributor whose work had been only begun.

J. WALTER WILSON

The foregoing resolutions were unanimously adopted by the Executive Committee and the Secretary was instructed to send copies to the nearest relatives and to publish the resolutions in the Proceedings of the Society.

3. *Report of the Treasurer.* The Treasurer presented the following report for the year 1943:

Credits:			
Cash balance from 1942	$1,181.00		
U. S. $1,000 Savings Bonds M305107D and M305109D; present redemption value at $810	1,620.00		
Receipts from dues	2,882.00		
Total			$5,683.00
Expenditures:			
Secretary's Expenses:			
Stenographer and steno. supplies	187.20		
Printing, stationary, postage	93.33		
Travel	87.16		
Stipend	200.00		
		$ 567.69	
Treasurer's Expenses:			
Stenographer and Steno. supplies	26.25		
Postage	40.18		
Express charges	.82		
		67.25	
The Wistar Institute:			
Programs and abstracts	613.49		
Proceedings	298.96		
		912.45	
Biological Abstracts:			
Subscriptions through Treasurer	2.00		
Contribution from members	1,346.00		
		1,348.00	
Union of American Biological Societies:			
Contribution (1940, 1941)	20.00		
		20.00	
Members' refund		4.00	
Members' checks returned		4.00	
Total expenditures		$2,923.39	
Balance, December 20, 1943			
Checking account	1,139.61		
Two U. S. Savings Bonds at $810	1,620.00		
		2,759.61	
Total			$5,683.00
Total December 31, 1942			6,245.77
Decrease of funds handled by Treasurer during current year			562.77
Decrease in assets of the Society during the current year			21.39

4. *Report of the Auditing Committee.* The Auditing Committee consisting of Emil Witschi and Gordon Marsh presented the following report:

> We have examined the books and accounts of the Treasurer of the American Society of Zoologists and find them to be in order and correctly balanced. The Treasurer's annual report is in accord with the books.
>
> December 31, 1943.
>
> Signed: Emil Witschi
> Gordon Marsh

The Executive Committee voted to accept and approve the reports of the Treasurer and of the Auditing Committee.

5. *Support of Biological Abstracts.*

> Reports submitted by the Editor-in-Chief and Business Manager of Biological Abstracts show that the organization has stood up remarkably well considering the many difficulties confronting it. The reports indicate a need for continued financial support from Biological Societies and other organizations if prevailing standards are to be maintained. It was therefore recommended that the American Society of Zoologists provide the same financial support in 1944 as for 1943, namely, that $2.00 from each membership fee of $4.00 be paid to Biological Abstracts.

The Executive Committee upon careful examination of the reports submitted voted to approve this recommendation.

6. *Election of new members.* In accordance with the stipulations in the constitution regarding membership the following candidates were recommended for election to membership in the Society:

ACTIVE MEMBERS

Carpenter, Esther
Colin, Edward Cecil
Dunihue, Fred Williams
Kimball, Richard F.
Miller, James Albert
Nabrit, Samuel Milton
Pennak, Robert William
Plagge, James C.
Self, John Teague
Stilwell, E. Frances
Villee, Claude Alvin, Jr.
Welch, D'Alte Aldridge
Williams, Carroll Milton
Worley, Leonard George

(Not Formerly Associate Members)

Andrews, Frederick Newcomb
Beach, Frank A.
Bogart, Ralph
Eversole, Wilburn John
Hamilton, Howard Laverne
Hollander, Willard Fisher
Hopkins, Sewell Hepburn
Langlois, Thomas Huxley
Mendoza, Guillermo
Rogick, Mary Dora
Tyler, Albert

NEW ASSOCIATE MEMBERS

Altland, Paul Daniel
Bryson, Vernon
Evans, Francis Gaynor
Farner, Donald S(ankey)
Foulks, James Grigsby
Gayer, H. Kenneth
Goodchild, Chauncey G.
Grobman, Arnold Brams
Guhl, Alphaeus Matthew
Hardcastle, Aaron Bascom
Hauschka, Theodore Spaeth
Hunter, Wanda Sanborn
Johnson, Leland Parrish
Keck, Warren N.
Kelsall, Margaret Aston
Leonard, Arthur Byron
Lochhead, John Hutchison
Morgan, Charles Frederick
Ris, Hans
Rose, S(ylvan) Meryl
Rubin, David
Simmons, George Finlay
TeWinkel, Lois Evelyn
Venard, Carl Ernest
Watterson, Ray Leighton
Wilhelmi, Raymond Wm.
Wimsatt, William Abel
Wolterink, Lester Floyd
Wright, Philip Lincoln

The Executive Committee, in accordance with the powers granted by referendum, voted that the above named candidates be declared elected to the classes of membership indicated and instructed the Secretary to cast one ballot in their favor.

7. *Changes in membership.* For the information of the Society the Secretary reports the following changes in membership which have occurred during the past year. The following summary includes the above newly elected candidates:

Deaths	6	New associate members	29
Resignations	1	Reinstated	0
Dropped	0	New active members	11
	7		40

Total enrollment in last report	1,029
Gain in enrollment	33
Total enrollment at present	1,062

8. *Election of officers.* The Nominating Committee consisting of C. E. McClung, Chairman; Ethel Browne Harvey, and T. M. Sonneborn, presented the following report:

President, 1 year: Sewall Wright.

Vice-President, 1 year: H. W. Stunkard.

Executive Committeeman, 5 years: T. S. Painter.

Society Representative in the Division of Biology and Agriculture of the National Research Council, 3 years: C. W. Metz; D. M. Whitaker, alternate.

Society Representatives on the Council of the American Association for the Advancement of Science, 1 year: G. A. Baitsell; P. W. Whiting.

Society Representatives on the Council of the Union of American Biological Societies, 1 year: F. Schrader; H. B. Steinbach.

Society Representatives on the Advisory Editorial Board of Biological Abstracts: P. B. Armstrong; A. I. Ortenburger; A. Franklin Shull; H. J. VanCleave.

Society Representative on the Executive Committee of the Biological Stain Commission: S. I. Kornhauser.

Members of the Editorial Board of the Journal of Morphology, 3 years: H. B. Baker; Hope Hibbard; R. L. King.

The Executive Committee by unanimous vote declared the above named candidates elected to the offices indicated and instructed the Secretary to cast one ballot in their favor.

9. Committee Reports. (a) The War Emergency Subcommittee of the Executive Committee consisting of C. G. Hartman, Chairman; M. H. Jacobs, J. S. Nicholas, L. L. Woodruff, and T. S. Painter and L. V. Domm, Ex officio, presented the following report:

Since the last report of the chairman of the Committee, little has been attempted, for several reasons. First, the draft had proceeded to the point where there were almost no single men, subject to the draft, left on zoological staffs; i.e., the available personnel were in the armed services. Through the intervention of heads of departments, many men were placed in activities suited to their training. The Man Power Board is even now biology conscious only in certain areas, such as the food supply, nutrition and sanitation. Secondly, the Division of Biology and Agriculture, under Dr. Robert F. Griggs, were valiantly and militantly at work seeking to interpret the place of Biology in the war effort. The Committee secured the services of Dr. Douglas M. Whitaker of Stanford to assist in these activities. Progress reports sent out in bimonthly bulletins by Dr. Griggs have been on the whole discouraging, notably that of October, 1943. The need is emphasized for the organization of an Institute of Biology, consolidating the 25 or more Biological Societies after the manner in which the 4 Physical Societies constitute the Institute of Physics.

(b) The following report by S. I. Kornhauser, Representative of the Society on the Executive Committee of the Biological Stain Commission, was presented:

Your representative has had a busy year with the work of the Commission. He has been occupied not only with the routine testing of submitted batches of dyes and the reading of papers for Stain Technology, but also with the reorganization of the Commission upon a more permanent basis.

In February we had a meeting of the Executive Committee in Philadelphia. At that time, it was deemed advisable that the Commission should incorporate. The accumulated funds earned from certification of large amounts of stains for the armed forces, and lend-lease had reached such proportions as to make a considerable sum for future use. These funds to be wisely invested and safeguarded for years to come, we felt, would be better protected by a board of trustees of a recognized corporation. Accordingly, a petition for incorporation and by-laws were drawn up and adopted. We have applied for a charter under the Regents of the University of the State of New York.

During the year we have also established a pension fund directed by a board of trustees of which your representative is chairman. The fund will provide retiring annuities for those workers of the Commission who receive salaries and who have served the organization for a number of years.

The Commission has not taken on any new projects connected with stain standardization. Although there has been some demand that we undertake the standardization of biological dyes in regard to their bacteriostatic and therapeutic activities. Several of us felt this was not within our sphere, but more in the field of pharmacology which we did not wish to invade.

(c) The Motion Picture Committee, consisting of Ralph Buchsbaum, Robert Chambers, Jr., and O. W. Richards, working with E. J. Farris, representative of The Wistar Institute, submitted the following report:

The Motion Picture Committee of the American Society of Zoologists, along with a similar committee representing the American Association of Anatomists, has continued its cooperation during the past year with The Wistar Institute in evaluating and reviewing films in biology.

A question has been raised regarding the advisability of continuing to publish reviews of approved films in Zoology in The Anatomical Record. It is suggested that films of interest particularly to Zoologists should have reviews and abstracts of these published in one of the zoological journals of The Wistar Institute.

The Committee solicits the aid of Zoologists in providing zoological films for viewing in an effort to complete and make known all films available in zoology.

The Executive Committee voted to approve the foregoing Committee reports.

10. Nominating Committee for 1944. The President appointed the following nominating committee to prepare a slate of officers for 1944: Carl G. Hartman, Chairman; Charles Packard, and David H. Wenrich.

L. V. Domm
Secretary

LIFE AND ACTIVE MEMBERS

(* indicates life members of the Society; † indicates charter members of the American Morphological Society; mail addresses are in italics.)

ABRAMOWITZ, ALEXANDER ALBERT, B.A. (St. Stephen's), M.A., Ph.D. (Harvard), Research Assistant, *Biological Laboratories, Harvard University, Cambridge, Mass.*

ACKERT, JAMES EDWARD, A.B., A.M., Ph.D. (Illinois), Professor of Zoology and Parasitologist, Agricultural Experiment Station; Dean, Graduate School; *Kansas State College, Manhattan, Kan.*

ADAMS, A. ELIZABETH, B.A. (Mt. Holyoke), M.A. (Columbia), Ph.D. (Yale), Professor of Zoology, *Mount Holyoke College, South Hadley, Mass.*

ADAMS, LEVERETT ALLEN, A.B., A.M. (Kansas), Ph.D. (Columbia), Professor of Zoology, Curator of the Museum of Natural History, University of Illinois, *401 Vermont St., Urbana, Ill.*

ADAMSTONE, FRANK BOLTON, B.A., M.A., Ph.D. (Toronto), Associate Professor of Zoology, *345 Natural History Building, University of Illinois, Urbana, Ill.*

ADELMANN, HOWARD BERNHARDT, A.B., A.M., Ph.D. (Cornell), Professor of Histology and Embryology, *Department of Zoology, Cornell University, Ithaca, N. Y.*

ADOLPH, EDWARD FREDERICK, A.B., Ph.D. (Harvard), Associate Professor of Physiology, School of Medicine, *University of Rochester, Rochester, N. Y.*

ALEXANDER, (EDWARD) GORDON, A.B. (Central), A.M., Ph.D. (Princeton), Professor of Biology, *University of Colorado, Boulder, Colo.*

ALLEE, WARDER CLYDE, S.B., LL.D. (Earlham), S.M., Ph.D. (Chicago), Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

ALLEN, BENNET, Ph.B. (De Pauw), Ph.D. (Chicago), Professor of Zoology, University of California, Los Angeles, *909 Micheltorena St., Los Angeles, Calif.*

ALLEN, WILLIAM RAY, A.B., A.M., Ph.D. (Indiana), Professor of Zoology, *Department of Zoology, University of Kentucky, Lexington, Ky.*

ALTENBURG, EDGAR, A.M., Ph.D. (Columbia), Assistant Professor of Biology, *Rice Institute, Houston, Texas.*

ANDERSON, BERTIL G., A.B. (Augustana), M.S., Ph.D. (Iowa), Assistant Professor of Zoology, *Department of Botany and Zoology, West Virginia University, Morgantown, W. Va.*

†*ANDREWS, ETHAN ALLEN, Ph.B. (Yale), Ph.D. (Johns Hopkins), Professor of Zoology, Emeritus, *The Johns Hopkins University, Baltimore, Md.*

ANDREWS, FREDERICK NEWCOMB, B.S., M.S. (Massachusetts State), Ph.D. (Missouri), Associate in Agricultural Experiment Station and Assistant Professor of Animal Husbandry, Purdue University, *Agricultural Experiment Station, Purdue University, Lafayette, Ind.*

ANGERER, CLIFFORD A., A.B. (Columbia), Ph.D. (Pennsylvania), Assistant Professor of Physiology, *Department of Physiology, Ohio State University, Columbus, Ohio.*

AREY, LESLIE BRAINERD, Ph.D. (Harvard), Sc.D. (Colby), Robert L. Rea Professor of Anatomy and Chairman of the Division of Anatomy, *Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

ARMSTRONG, PHILIP B., B.S. (Mass. State), M.D. (Cornell), Professor of Anatomy, *Department of Anatomy, College of Medicine, Syracuse University, Syracuse, N. Y.*

BAGG, HALSEY JOSEPH, B.S., A.M., Ph.D. (Columbia), Research Fellow in Biology, Huntington Fund for Cancer Research, Cornell University Medical College, *Memorial Hospital, 68th St. and York Ave., New York, N. Y.*

BAITSELL, GEORGE ALFRED, B.S. (Central College, Iowa), M.A., Ph.D. (Yale), Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

BAILEY, PERCY LAURANCE, JR., A.B., Ph.D. (Brown), Assistant Professor of Biology, *College of the City of New York, Convent Ave. and 139th St., New York, N. Y.*

BAKER, HORACE BURRINGTON, B.S., Ph.D. (Michigan), Professor of Zoology, University of Pennsylvania, *Zoological Laboratory, University of Pennsylvania, Philadelphia, Pa.*

BALL, GORDON HAROLD, B.S., M.S. (Pittsburgh), Ph.D. (California), Associate Professor of Zoology, *University of California, Los Angeles, Calif.*

BALL, STANLEY CRITTENDEN, Ph.B., Ph.D. (Yale), Associate Professor of Biology and Curator of the Zoological Collection, *Peabody Museum, Yale University, New Haven, Conn.*

BANGHAM, RALPH VANDERVORT, A.B. (Wilmington), B.S., A.M. (Haverford), Ph.D. (Ohio State), Professor of Biology and Head of the Department, *Wooster College, Wooster, Ohio.*

BANTA, ARTHUR MANGUN, A.B., A.M. (Indiana), Ph.D., (Harvard), Research Professor of Biology, Brown University, *Biology Department, Brown University, Providence, R.I.*

BARBOUR, THOMAS, A.B., A.M., Ph.D. (Harvard), Sc.D. (Havana, Dartmouth), S.D. (Harvard), Professor of Zoology; Director, Harvard University Museum and *Museum of Comparative Zoology, Cambridge, Mass.*

BARNES, THOMAS CUNLIFFE, B.A. (Cornell), D.Sc. (Harvard), Associate Professor of Physiology, *Hahnemann Medical College, Philadelphia, Pa.*

BARROWS, WILLIAM MORTON, B.S. (Michigan Agricultural College), S.B., S.M., S.D. (Harvard), *Department of Zoology and Entomology, Ohio State University, Columbus, Ohio.*

BARTELMEZ, GEORGE WILLIAM, Ph.D. (Chicago), Professor of Anatomy, *Hull Anatomical Laboratory, The University of Chicago, Chicago 37, Ill.*

BARTH, LESTER G., A.B. (Wayne University, Detroit), A.M. (Michigan), Ph.D. (Chicago), Assistant Professor of Zoology, *Department of Zoology, Columbia University, New York, N. Y.*

BARTSCH, PAUL, B.S., M.S., Ph.D. (State University of Iowa), Sc.D. (George Washington), Professor of Zoology, Emeritus, George Washington University; Curator of the Divisions of Mollusks and Cenozoic Invertebrates, *United States National Museum, Washington, D. C.*

BAUMGARTNER, WILLIAM JACOB, A.B., A.M. (Kansas), Ph.D. (Munich), Professor of Zoology, University of Kansas, *1209 Ohio St., Lawrence, Kan.*

BEACH, FRANK A., B.S., M.S. (Kansas State Teachers), Ph.D. (Chicago), Chairman and Curator, *Department of Animal Behavior, American Museum of Natural History, Central Park West at 79th St., New York 24, N. Y.*

BEADLE, GEORGE WELLS, B.S., M.S. (Nebraska), Ph.D. (Cornell), Professor of Biology (Genetics), *Department of Biology, Stanford University, Stanford University, Calif.*

BEAMS, HAROLD WILLIAM, A.B. (Fairmount), M.A. (Northwestern), Ph.D. (Wisconsin), Professor of Zoology, *Zoology Department, State University of Iowa, Iowa City, Iowa.*

BEAN, ELIZABETH SMITH, A.B. (Cincinnati), M.A., Ph.D. (Wisconsin), Instructor in Histology and Embryology, *Dalhousie University, 28 Chestnut St., Halifax, Nova Scotia.*

BECCARI, NELLO, M.D. (Florence), Professor of Comparative Anatomy, *Instituto di Anatomica Comparata. Via Romana, 19, Florence, Italy.*

BECK, LYLE VIBERT, A.B. (Wabash College), M.S. (Washington University), Ph.D. (Pittsburgh), Instructor in Physiology, *Hahnemann Medical College, Philadelphia, Pa.*

BECKER, ELERY RONALD, A.B. (Colorado), Sc.D. (Johns Hopkins), Professor of Zoology, *Iowa State College, Ames, Iowa.*

BECKWITH, CORA JIPSON, B.S. (Michigan), M.A., Ph.D. (Columbia), Professor of Zoology, Emeritus, *Vassar College, Poughkeepsie, N. Y.*

BEERS, CHARLES DALE, A.B., A.M. (North Carolina), Ph.D. (Johns Hopkins), Professor of Zoology, University of North Carolina, *Box 328, Chapel Hill, N. C.*

BEHRE, ELLINOR HELENE, A.B. (Radcliffe), Ph.D. (Chicago), Professor of Zoology, Louisiana State University, *Box 8729, University Station, Baton Rouge 3, La.*

BENNETT, HARRY JACKSON, B.S. (Louisiana), M.S., Ph.D. (Illinois), Associate Professor of Zoology and Assistant to the Dean of the College of Arts and Sciences, *Louisiana State University, Baton Rouge, La.* (On leave for military service, '42. Capt., U. S. A.)

BENNITT, RUDOLF, S.B., A.M. (Boston), A.M., Ph.D. (Harvard), Professor of Zoology, *University of Missouri, Columbia, Mo.*

BERGER, CHARLES ALBERT, A.B., M.A. (Boston College), Ph.D. (Johns Hopkins), Professor of Cytology, Director of the Biological Laboratory, *Fordham University, New York, N. Y.*

BERTHOLF, LLOYD MILLARD, A.B. (Southwestern), A.M., Ph.D. (Johns Hopkins), Dean of the Faculty and Professor of Biology, *Western Maryland College, Westminister, Md.*

Bevelander, Gerrit, A.B. (Hope), A.M. (Michigan), Ph.D. (Johns Hopkins), Associate Professor of Anatomy, *New York University, College of Dentistry, 477 First Ave., New York 16, N. Y.*

Bigelow, Henry B., A.B., A.M., Ph.D. (Harvard), Sc.D. (Yale), Professor of Zoology, Harvard University; Curator of Oceanography, Museum of Comparative Zoology, *Museum of Comparative Zoology, Cambridge, Mass.*

Bigelow, Maurice Alpheus, B.S., LL.D. (Ohio Wesleyan), M.S. (Northwestern), Ph.D. (Harvard), Sc.D. (Columbia), Professor of Biology, Emeritus, Teachers College, Columbia University, *525 W. 120th St., New York, N. Y.*

Bishop, Sherman C., B.S., Ph.D. (Cornell), Professor of Vertebrate Zoology, *University of Rochester, Rochester, N. Y.*

Bissonnette, Thomas Hume, M.A. (Queens), Ph.D. (Chicago), Professor of Biology and Head of the Department, *Trinity College, Hartford, Conn.*

Blake, Charles Henry, S.B., Ph.D. (Massachusetts Institute of Technology), Assistant Professor of Zoology, *Massachusetts Institute of Technology, Cambridge, Mass.*

Blandau, Richard Julius, A.B. (Linfield), Ph.D. (Brown), Instructor in Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*

Bloom, William, A.B., M.D. (Johns Hopkins), Professor of Anatomy, *Hull Anatomical Laboratory, The University of Chicago, Chicago 37, Ill.*

Blount, Raymond Frank, B.S.A., M.S. (Arizona), Ph.D. (Yale), Assistant Professor of Anatomy, *University of Minnesota, Minneapolis, Minn.*

Blum, Harold Francis, A.B., Ph.D. (California), Principal Biologist (Biophysics), *Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md.*

Bodenstein, Dietrich, *Department of Zoology, Columbia University, New York, N. Y.*

Bodine, Joseph Hall, A.B., Ph.D. (Pennsylvania), Professor of Zoology, *Zoological Laboratory, State University of Iowa, Iowa City, Iowa.*

Boell, Edgar John, B.A. (Dubuque), Ph.D. (Iowa), Associate Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

Bogart, Ralph, B.S. (Missouri), M.S. (Kansas State), Ph.D. (Cornell), Agent in Animal Husbandry (Cooperative) United States Department of Agriculture and Assistant Professor of Animal Husbandry, *Department of Animal Husbandry, University of Missouri, Columbia, Mo.*

Boring, Alice Middleton, A.B., A.M., Ph.D. (Bryn Mawr), Professor of Anatomy, (ad interim) College of Physicians and Surgeons, Columbia University, *633 West 168th St., New York, N. Y.*

Boughton, Donald Clarke, B.S. (Pittsburgh), M.S. (Minnesota), Ph.D. (Wisconsin), Assistant Professor, *Department of Zoology, University of Georgia, Athens, Ga.*

Bozler, Emil, Ph.D. (Munich), Associate Professor, *Department of Physiology, Hamilton Hall, Ohio State University, Columbus, Ohio.*

Boyden, Alan Arthur, A.B., Ph.D. (Wisconsin), Associate Professor of Zoology, *Rutgers University, New Brunswick. N. J.*

Boyden, Edward Allen, A.B., A.M., Ph.D. (Harvard), Professor of Anatomy and Chairman of the Department, *University of Minnesota, School of Medicine, Minneapolis, Minn.*

BRAGG, ARTHUR NORRIS, B.S. (Bates), M.A. (Boston University), Ph.D. (Oklahoma), Assistant Professor of Zoology, *Department of Animal Biology, University of Oklahoma, Norman, Okla.*

BRAMBEL, CHARLES EUGENE, A.M., Ph.D. (Johns Hopkins), Instructor in Zoology, *The Johns Hopkins University;* Biochemist, *Mercy Hospital, Baltimore, Md.*

BRANCH, HAZEL E(LISABETH), A.B., A.M. (Kansas), Ph.D. (Cornell), Professor of Zoology, Head of Department, *University of Wichita, Wichita, Kan.*

BRAUER, ALFRED, A.B. (Kansas), M.A. (Oklahoma), Ph.D. (Chicago), Professor of Zoology, *University of Kentucky, Lexington, Ky.*

BREDER, CHARLES MARCUS, JR., D.Sc. (Newark), Director, New York Aquarium, Bronx Park, New York, N. Y., and Research Associate, *American Museum of Natural History, New York, N. Y.*

BRELAND, OSMOND P., B.S. (Mississippi State), Ph.D. (Indiana), Assistant Professor of Zoology, *University of Texas, Austin, Texas.*

BRENEMAN, WILLIAM RAYMOND, A.B. (Indiana Central College), Ph.D. (Indiana University), Associate Professor, Waterman Institute and Zoology Department, *Indiana University, Bloomington, Ind.*

BRINLEY, FLOYD JOHN, B.S. (Colorado State), M.A., Ph.D. (Pennsylvania), Biologist, *U. S. Public Health Service, State Department of Health, Austin, Texas.*

BROWMAN, LUDVIG GUSTAV, B.S., Ph.D. (Chicago), Associate Professor of Zoology, *Department of Zoology, Montana State University, Missoula, Mont.*

BROWN, FRANK ARTHUR, JR., A.B. (Bowdoin), A.M., Ph.D. (Harvard), Associate Professor of Zoology, *Department of Zoology, Northwestern University, Evanston, Ill.*

BROWN, LELAND ARTHUR, S.B. (Denison), A.M. (Pittsburgh), Ph.D. (Harvard), Professor of Biology, *Transylvania College, Lexington, Ky.*

BROWN, MORDEN GRANT, A.B., A.M., Ph.D. (Stanford), *Spencer Lens Company, Buffalo, N. Y.*

BRUES, CHARLES THOMAS, B.S., M.S. (Texas), A.M. (Harvard), Professor of Entomology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

BRUNER, HENRY LANE, A.B. (Eureka-Abingdon), Ph.D. (Freiburg), Professor of Zoology, Emeritus, Butler University, *324 S. Ritter Ave., Indianapolis, Ind.*

BUCHANAN, JAMES WILLIAM, B.S. (Ohio), Ph.D. (Chicago), Professor of Zoology, *Northwestern University, Evanston, Ill.*

BUCHSBAUM, RALPH, B.S., Ph.D. (Chicago), Assistant Professor of Zoology in the College, *The University of Chicago, Chicago 37, Ill.* (On leave for military service, '42. Captain, U. S. A. Air Force.)

BUCK, JOHN BONNER, A.B., Ph.D. (Johns Hopkins), Assistant Professor of Zoology, *Department of Zoology, University of Rochester, Rochester, N. Y.*

BUDINGTON, ROBERT ALLYN, B.A., M.A., D.Sc. (Williams), Professor of Zoology, Emeritus, Oberlin College, Oberlin, Ohio. *185 Sylvan Blvd., Winter Park, Fla.*

BULLINGTON, WALTER EDWARD, B.S., M.S. (Tennessee), Ph.D. (Kansas), Professor of Biology, *Randolph-Macon College, Ashland, Va.*

BURGER, J. WENDELL, A.B. (Haverford), A.M. (Lehigh), Ph.D. (Princeton), Assistant Professor of Biology, *Department of Biology, Trinity College, Hartford, Conn.*

BURKENROAD, MARTIN DAVID, Assistant Curator, Bingham Oceanographic Collection, Yale University, *55 Hillhouse Ave., New Haven, Conn.*

BURNS, ROBERT KYLE, JR., A.B. (Bridgewater), Ph.D. (Yale), Research Associate, *Carnegie Laboratory of Embryology, The Johns Hopkins Medical School, Baltimore 5, Md.*

BURT, CHARLES EARLE, B.S., M.S. (Kansas State), Ph.D. (Michigan), Professor of Biology, *Southwestern College, Winfield, Kan.*

BUTCHER, EARL ORLO, A.B. (De Pauw), A.M., Ph.D. (Cornell), Professor of Anatomy, *Department of Anatomy, New York University College of Dentistry, 477 First Ave., New York City, N. Y.*

BUTLER, ELMER GRIMSHAW, A.B., Sc.D. (Syracuse), A.M., Ph.D. (Princeton), Professor of Zoology, *Department of Biology, Princeton University, Princeton, N. J.*

BYERLY, THEODORE CARROLL, A.B., M.S., Ph.D. (Iowa), *Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C.*

BYRD, ELON E., B.S., M.S. (Mississippi State College), Ph.D. (Tulane), Assistant Professor of Zoology, *Department of Zoology, University of Georgia, Athens, Ga.*

BYRNES, ESTHER F., B.A., M.A., Ph.D. (Bryn Mawr), *1803 N. Camac St., Philadelphia, Pa.*

CABLE, RAYMOND M., A.B. (Berea), M.S., Ph.D. (New York University), Associate Professor of Zoology, *Purdue University, Lafayette, Ind.*

CALVERT, PHILIP POWELL, Ph.D. (Pennsylvania), Professor of Zoology, Emeritus, University of Pennsylvania, *Box 14, Cheyney, Pa.*

CAMERON, JOHN ANDREW, A.B., A.M. (Nebraska), Ph.D. (Missouri), Associate Professor of Anatomy, *School of Medicine, University of Missouri, Columbia, Mo.*

CAMPBELL, ARTHUR SHACKLETON, A.B. (Pomona), A.M. (Harvard), Ph.D. (California), Professor of Zoology, *Saint Mary's College, St. Mary's, Calif.*

CARLSON, JAMES GORDON, A.B., Ph.D. (Pennsylvania), Assistant Professor of Zoology, *Department of Biology, University of Alabama, University, Ala.*

CAROTHERS, E. ELEANOR, A.B., A.M. (Kansas), Ph.D. (Pennsylvania), *134 Ave. C, East, Kingman, Kan.*

CARPENTER, ESTHER, B.A. (Ohio Wesleyan), M.S. (Wisconsin), Ph.D. (Yale), Associate Professor of Zoology, *Smith College, Burton Hall, Northampton, Mass.*

CARROLL, MITCHEL, B.S., Ph.D. (Pennsylvania), Sc.D. (Franklin and Marshall), Professor of Biology, *Franklin and Marshall College, Lancaster, Pa.*

CASPARI, ERNST WOLFGANG, Ph.D. (Goettingen), Assistant Professor of Biology, *Department of Biology, Lafayette College, Easton, Pa.*

CASTEEL, DANA BRACKENRIDGE, A.B. (Allegheny), A.M. (Ohio Wesleyan), Ph.D. (Pennsylvania), Professor of Zoology, *University of Texas, Austin, Texas.*

CASTLE, WILLIAM A., B.S. (Denison), Ph.D. (Chicago), Professor of Biology, *Mary Washington College, Box 1331, Fredericksburg, Va.*

CASTLE, WILLIAM E., A.B. (Denison), A.M., Ph.D. (Harvard), Research Associate in Genetics, *Hilgard Hall, University of California, Berkeley, Calif.*

CAUSEY, DAVID, A.B. (James Millikin), A.M. (Illinois), Ph.D. (California), Professor of Zoology, *University of Arkansas, Fayetteville, Ark.*

Chalkley, Harold William, B.S. (Mississippi A. and M.), M.A., Ph.D. (Johns Hopkins), Physiologist, *National Cancer Institute, U. S. Public Health Service, Bethesda, Md.*

Chambers, Robert, Jr., A.B. (Robert), M.A. (Queen's University, Canada), Ph.D. (Munich), Research Professor of Biology, New York University, *Washington Square College, Washington Square, New York, N. Y.*

Charipper, Harry Adolph, B.S., M.S., Ph.D. (New York), Professor of Biology and Chairman of the Department, *Washington Square College, 100 Washington Square East, New York, N. Y.*

Chase, Aurin Moody, B.A., M.A. (Amherst), Ph.D. (Columbia), Research Associate and Instructor, *Department of Biology, Princeton University, Princeton, N. J.*

Chase, Samuel Wood, A.B. (Bowdoin), A.M., Ph.D. (Harvard), Associate Professor of Histology and Embryology, *Western Reserve University, School of Medicine, 2109 Adelbert Road, Cleveland, Ohio.*

Chen, Tze-Tuan, B.A. (Fukien Christian University), M.A. (Oberlin), Ph.D. (Pennsylvania), Lecturer in Zoology, *Department of Zoology, University of California at Los Angeles, Los Angeles, Calif.*

Cheney, Ralph Holt, B.S., A.M. (Boston), Sc.M., Sc.D. (Harvard), Professor of Biology and Chairman of the Department of Biology; Chairman of the Division of Natural and Physical Sciences, *Long Island University, Brooklyn, N. Y.*

Chesley, L. C., Ph.D. (Duke), Biochemist, *Margaret Hague Maternity Hospital, Jersey City, N. J.*

Chester, Wayland Morgan, A.B., A.M., Sc.D. (Colgate), D.Sc. (Hon.) (Hillsdale), Professor of Biology, *Colgate University, Hamilton, N. Y.*

Chickering, Arthur Merton, Ph.B. (Yale), M.S. (Wisconsin), Ph.D. (Michigan), Professor of Biology; Chairman, Division of Science and Mathematics; Chairman, Divisional Council, *Department of Biology, Albion College, Albion, Mich.*

Child, Charles Manning, Ph.B., M.S. (Wesleyan), Ph.D. (Leipzig), D.Sc. (Wesleyan), Professor of Zoology, Emeritus, The University of Chicago, *Jordan Hall, Stanford University, Calif.*

Child, George Percy, B.S., Ph.D. (New York), Assistant Professor, *Amherst College, Amherst, Mass.*

Churchill, Edward Perry, A.B. (Iowa), Ph.D. (Johns Hopkins), Professor of Zoology and Head of the Department, University of South Dakota, *415 South University St., Vermillion, S. D.*

Clark, Leonard B., A.B., M.A., (Manitoba), M.A., Ph.D. (Johns Hopkins), Associate Professor of Biology, *Department of Biology, Union College, Schenectady, N. Y.*

Clarke, George Leonard, A.B., A.M., Ph.D. (Harvard), Associate Professor of Zoology, Harvard University, and Marine Biologist, Woods Hole Oceanographic Institution, *Biological Laboratories, Harvard University, Cambridge, Mass.*

Claus, Pearl E(lizabeth), A.B., M.A., Ph.D. (Wisconsin), Research Associate in Zoology, *Biology Building, University of Wisconsin, Madison, Wis.*

Clausen, Harry John, A.B., M.S. (Iowa), Ph.D. (New York), Assistant Professor of Anatomy, *University of Colorado, School of Medicine, Denver, Colo.*

CLEMENS, WILBERT AMIE, B.A., M.A. (Toronto), Ph.D. (Cornell), Professor of Zoology, *University of British Columbia, Vancouver, British Columbia, Canada.*

CLEVELAND, LEMUEL ROSCOE, B.S. (Mississippi), D.Sc. (Johns Hopkins), Associate Professor of Zoology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

COE, WESLEY R., Ph.B., Ph.D. (Yale), Professor of Biology, Emeritus, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

COKER, ROBERT ERVIN, B.S., M.S. (North Carolina), Ph.D. (Johns Hopkins), Kenan Professor of Zoology, *University of North Carolina, Chapel Hill, N. C.*

COLE, ELBERT CHARLES, A.B. (Middlebury), A.M. (Trinity), Ph.D. (Harvard), Professor of Biology, *Williams College, Williamstown, Mass.*

COLE, LEON J., A.B. (Michigan), Ph.D. (Harvard), Professor of Genetics, University of Wisconsin, *College of Agriculture, University of Wisconsin, Madison, Wis.*

COLE, WILLIAM H(ARDER), A.B. (Hamilton), A.M., Ph.D. (Harvard), Professor of Physiology and Biochemistry, Rutgers University, *Rutgers University, New Brunswick, N. J.*

COLIN, EDWARD CECIL, A.B. (Kansas), Ph.D. (Chicago), Professor of Zoology and Genetics, Chicago Teachers College, *6567 Harvard Ave., Chicago, Ill.*

COLLETT, MARY ELIZABETH, A.B. (Wellesley), A.M., Ph.D. (Pennsylvania), Associate Professor of Biology, *Mather College, Western Reserve University, Cleveland, Ohio.*

COLTON, HAROLD SELLERS, B.S., M.A., Ph.D. (Pennsylvania), Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*, Director of the Museum of Northern Arizona, *Flagstaff, Ariz.*

CONKLIN, EDWIN GRANT, Ph.D. (Johns Hopkins), D.Sc. (Pennsylvania, Yale), LL.D. (Western Reserve, Johns Hopkins), Research Professor of Biology, Emeritus, *Princeton University, Princeton, N. J.*, President, *American Philosophical Society, Independence Square, Philadelphia, Pa.*

COONFIELD, BENJAMIN RANDOLPH, B.S. (Arkansas), M.S. (Kansas State), Ph.D. (Harvard), Associate Professor of Biology, *Department of Biology, Brooklyn College, Bedford Avenue and Avenue H, Brooklyn, N. Y.*

COOPER, KENNETH W., A.B., M.A., Ph.D. (Columbia), Assistant Professor of Biology, *Princeton University, Princeton, N. J.*

COPELAND, MANTON, S.B., S.M., Ph.D. (Harvard), Professor of Biology, *Bowdoin College, Brunswick, Me.*

COPENHAVER, WILFRED MONROE, A.B., Ph.D. (Yale), Associate Professor of Anatomy, *College of Physicians and Surgeons, 630 W. 168th St., New York, N. Y.*

COREY, EDWARD LYMAN, A.B. (Western Reserve), Ph.D. (Yale), Assistant Professor of Physiology, *Department of Physiology, School of Medicine, University of Virginia, University, Va.*

CORT, W(ILLIAM) W(ALTER), A.B. (Colorado College), A.M., Ph.D. (Illinois), Professor of Parasitology, *School of Hygiene and Public Health, The Johns Hopkins University, 615 N. Wolfe St., Baltimore, Md.*

COSTELLO, DONALD PAUL, A.B. (College of the City of Detroit), Ph.D. (Pennsylvania), Professor of Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.*

Cowdry, Edmund Vincent, B.A. (Toronto), Ph.D. (Chicago), Professor of Anatomy, *Washington University School of Medicine, St. Louis 10, Mo.*

Cowles, Rheinart Parker, A.B. (Stanford), Ph.D. (Johns Hopkins), Professor of Zoology, Emeritus, College of Arts and Sciences, *Department of Biology, The Johns Hopkins University, Baltimore, Md.*

Crabb, Edward D., A.B., M.A. (Oklahoma), Ph.D. (Michigan), Professor of Biology, *Department of Biology, University of Colorado, Boulder, Colo.*

Crampton, Henry Edward, A.B., Ph.D., Sc.D. (Columbia), Professor of Zoology, Emeritus, Columbia University, Research Associate, *American Museum of Natural History, New York, N. Y.*

Creaser, Charles W., A.B., M.S., Ph.D. (Michigan), Professor of Zoology, *Wayne University, Detroit, Mich.*

Creighton, William Steel, B.S. (Roanoke), M.A. (Princeton), M.S., D.Sc. (Harvard), Assistant Professor of Biology, *College of the City of New York, 139th St. and Convent Ave., New York, N. Y.*

Crescitelli, Frederick, Ph.B., Sc.M., Ph.D. (Brown), Visiting Assistant Professor of Aviation Physiology, *University of Southern California, Los Angeles 7, Calif.*

Cross, James Cecil, A.B. (Southwestern), M.A., Ph.D. (Texas), Professor of Zoology and Head of the Department of Zoology, *Texas College of Arts and Industries, Kingsville, Texas.*

Curtis, Maynie Rose, A.B., A.M., Ph.D. (Michigan), Associate in Cancer Research, Institute of Cancer Research, Columbia University, *630 W. 168th St., New York, N. Y.*

Curtis, Winterton Conway, A.B., A.M. (Williams), Ph.D. (Johns Hopkins), D.Sc. (Williams), Dean of Faculty College of Arts and Sciences and Professor of Zoology, University of Missouri, *210 Westmount Ave., Columbia, Mo.*

Dahlgren, Ulric, A.B., M.S. (Princeton), Professor of Biology, Emeritus, *Princeton University, Princeton, N. J.*

Dalton, Albert Joseph, B.S. (Wesleyan), M.A., Ph.D. (Harvard), Research Fellow, Cytologist, *National Cancer Institute, National Institute of Health, Bethesda, Md.*

Danforth, C(harles) H(askell), A.M., Sc.D. (Tufts), Ph.D. (Washington University), Professor of Anatomy, Stanford University, *607 Cabrillo, Stanford University, Calif.*

Darby, Hugh Hackland, B.Sc., M.A., Ph.D. (Columbia), Director of Vitamin Research, *The Borden Company, 350 Madison Ave., New York, N. Y.*

Davenport, Charles Benedict, B.S. (Brooklyn Polytech.), A.B., A.M., Ph.D. (Harvard), Secretary, Long Island Biological Association, Curator Whaling Museum, *Cold Spring Harbor, Long Island, N. Y.*

Davenport, Gertrude Crotty, B.S. (Kansas), *Cold Spring Harbor, Long Island, N. Y.*

Davis, David Edward, A.B. (Swarthmore), M.A., Ph.D. (Harvard), United States Public Health Service, Typhus Control, *41 Exchange Place, Atlanta 3, Ga.*

Davis, Herbert Spencer, Ph.B. (Wesleyan), Ph.D. (Harvard), Fish Pathologist, *Bureau of Fisheries, Washington, D. C.*

Dawson, Alden Benjamin, A.B. (Acadia), Ph.D. (Harvard), D.Sc. (Acadia), Professor of Zoology, Chairman of the Department of Biology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

Dawson, James Arthur, A.B. (Dalhousie), A.M., Ph.D. (Yale), Professor of Biology, Chairman Department of Biology, *College of the City of New York, 139th St. and Convent Ave., New York, N. Y.*

Dederer, Pauline Hamilton, A.B. (Barnard), A.M., Ph.D. (Columbia), Professor of Zoölogy, *Connecticut College, New London, Conn.*

De Garis, Charles Francis, M.D. (Washington), A.B. (Wisconsin), A.M., Ph.D. (Johns Hopkins), F.A.C.P., Professor of Anatomy, *University of Oklahoma, School of Medicine, Oklahoma City, Okla.*

Demeric, M(ilislav), Ph.D. (Cornell), Director, Department of Genetics, *Carnegie Institution of Washington, Cold Spring Harbor, N. Y.*

Dempster, Wilfrid Taylor, B.S., A.M., ScD. (Michigan), Instructor in Anatomy, Medical School, University of Michigan, *2111 Abbott St., Ann Arbor, Mich.*

Diller, Irene Corey, A.B. (George Washington), A.M., Ph.D. (Pennsylvania), Research Institute, *The Lankenau Hospital, Philadelphia, Pa.*

Diller, William Frey, A.B. (Franklin and Marshall), Ph.D. (Pennsylvania), Assistant Professor of Biology, *Dartmouth College, Hanover, N. H.*

Dobzhansky, Theodosius, Diploma (Kiev, Russia), Professor of Zoology, *Columbia University, New York, N. Y.*

Dodds, Gideon S., B.A., M.A. (Colorado), Ph.D. (Pennsylvania), Professor of Histology and Embryology, School of Medicine, West Virginia University, *829 Price St., Morgantown, W. Va.*

Dolley, William Lee, Jr., A.B., A.M. (Randolph-Macon), Ph.D. (Johns Hopkins), Professor of Biology, *University of Buffalo, Buffalo, N. Y.*

Domm, L(incoln) V(alentine), A.B. (North Central), Ph.D. (Chicago), Research Associate in Zoology, *Whitman Laboratory of Experimental Zoology, The University of Chicago, Chicago 37, Ill.*

Dorris, Frances (Sue), (Mrs. Douglas George Humm), A.B. (Smith), M.A., Ph.D. (Yale), Sigma Delta Epsilon Research Fellow in Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

Doyle, William Lewis, A.M., Ph.D. (Johns Hopkins), Research Associate in Pharmacology, *Department of Pharmacology, The University of Chicago, Chicago 37, Ill.*

Dreyer, William A., A.B. (Illinois), Ph.D. (Chicago), Assistant Professor of Zoology, Department of Zoology, *University of Cincinnati, Cincinnati, Ohio.*

Dunihue, Fred Williams, B.A. (Wabash), M.Sc., Ph.D. (New York University), Assistant Professor of Histology and Embryology, *College of Medicine, University of Vermont, Burlington, Vt.*

Dunn, L(eslie) C(larence), S.B. (Dartmouth), S.M., Sc.D. (Harvard), Professor of Zoology, *Columbia University, New York, N. Y.*

DuShane, Graham Phillips, B.A. (Wabash), Ph.D. (Yale), Assistant Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

Eakin, Richard Marshall, A.B., Ph.D. (California), Associate Professor of Zoology, and Chairman of *Department of Zoology, University of California, Berkeley, Calif.*

EASTLICK, HERBERT LEONARD, A.B. (Montana), M.S., Ph.D. (Washington University), Assistant Professor of Zoology, *State College, Washington, Pullman, Wash.*

EATON, THEODORE HILDRETH, JR., A.B. (Cornell), Ph.D. (California), Instructor in Biology, *Department of Biology, Union College, Schenectady, N. Y.*

EDMONDSON, CHARLES HOWARD, Ph.B., M.S., Ph.D. (Iowa), Professor of Zoology, *University of Hawaii, Honolulu, Hawaii.*

EGGLETON, FRANK EGBERT, A.B. (Hillsdale), A.M., Ph.D. (Michigan), Associate Professor of Zoology, *University of Michigan, Ann Arbor, Mich.*

ELIAS, HANS, Dr.phil. (Giessen), Professor of Histology and Embryology, Middlesex Veterinary School, *103 Riverview Ave., Waltham, Mass.*

ELLIOTT, ALFRED M., B.A. (Yankton), M.S., Ph.D. (New York University), Professor of Biology, *State Teachers College, Bemidji, Minn.*

ELLIOTT, RUSH, A.B. (Ohio University), A.M. (Ohio State University), Ph.D. (Michigan), Professor of Anatomy, Ohio University, *3 Marietta Ave., Athens, Ohio.*

EMERSON, ALFRED EDWARDS, B.S., M.A., Ph.D. (Cornell), Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

EMERY, FREDERICK EARL, D.V.M., M.S. (Kansas State), Ph.D. (Wisconsin), Associate Professor of Physiology, University of Buffalo, Buffalo, N. Y.

ENDERS, HOWARD E(DWIN), B.S., M.S. (Lebanon Valley), B.S. (Michigan), Ph.D. (Johns Hopkins), Professor of Zoology; Head of the Department of Biology; Dean of the School of Science, Purdue University, *249 Littleton St., West Lafayette, Ind.*

ENDERS, ROBERT KENDALL, A.B., Ph.D. (Michigan), Associate Professor of Zoology, *Department of Zoology, Swarthmore College, Swarthmore, Pa.*

ENGELS, WILLIAM LOUIS, B.S. (Notre Dame), Ph.D. (California), Associate Professor of Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.* (On leave for military service, '42. Sgt., U. S. A. Air Force.)

ESSEX, HIRAM E., B.S. (Knox), M.S., Ph.D. (Illinois), Associate, Division of Experimental Surgery and Pathology, Mayo Clinic, Associate Professor of Physiology, Mayo Foundation, University of Minnesota, *Institute of Experimental Medicine, Rochester, Minn.*

ETKIN, WILLIAM, B.S. (College of the City of New York), M.A. (Cornell), Ph.D. (Chicago), Instructor in Biology, *College of the City of New York, Convent Ave. and 139th St., New York, N. Y.*

EVANS, GERTRUDE, A.B. (Mount Holyoke), Ph.D. (Chicago), Instructor in Biology, *Department of Biology, Beloit College, Beloit, Wis.*

EVANS, LLEWELLYN THOMAS, A.B., M.A. (Denver), Ph.D. (Harvard), *3413 Wadsworth St., Wheatridge, Colorado.*

EVANS, TITUS CARR, B.A. (Baylor), M.S., Ph.D. (Iowa), Assistant Professor of Radiology, (Biology), *Radiology Research Laboratory, College of Physicians and Surgeons, Columbia University, New York, N. Y.*

EVERSOLE, WILBURN JOHN, A.B. (Berea College), M.S., Ph.D. (New York), Instructor in Biology, *Department of Biology, The Rice Institute, Houston, Texas.*

Fankhauser, Gerhard, Ph.D. (Berne, Switzerland), Associate Professor of Biology, *Princeton University, Princeton, N. J.*

Farris, Edmond J(ohn), B.A. (Buffalo), Ph.D. (Pennsylvania), Executive Director, Associate in Anatomy, *The Wistar Institute of Anatomy and Biology, Woodland Ave. and 36th St., Philadelphia 4, Pa.*

Fasten, Nathan, B.S. (College of the City of New York), Ph.D. (Wisconsin), Professor of Zoology, *Oregon State College, Corvallis, Ore.*

Fauré-Fremiet, Emmanuel, Docteur ès Sciences (Paris), Professeur, Directeur du Laboratoire d'Embryogénie Comparée, *Collège de France, Paris V^e, France.*

Fennell, Richard Adams, A.B. (Birmingham Southern), Ph.D. (Johns Hopkins), Assistant Professor of Zoology, *Department of Zoology, Michigan State College, East Lansing, Mich.*

Figge, Frank Henry John, A.B. (Colorado College), Ph.D. (Maryland), Associate Professor of Gross Anatomy, *University of Maryland, School of Medicine, Baltimore, Md.*

Finley, Harold Eugene, B.S. (Morehouse College), M.S., Ph.D. (Wisconsin), Professor of Biology, *Department of Biology, Morehouse College, Atlanta, Ga.*

Foerster, Russell Earle, B.A., M.A. (British Columbia), Ph.D. (Toronto), Director, Pacific Biological Station, *Nanaimo, British Columbia, Canada.*

Fogg, Lloyd C(larke), B.S., M.S. (Dartmouth), Ph.D. (Columbia), *Boston University School of Medicine, 803 Concord St., Boston, Mass.*

Folger, Harry Thomas, A.B. (Indiana), Ph.D. (Johns Hopkins), Research Professor of Biology, *Box 161, Fisk University, Nashville, Tenn.*

Forster, Roy Philip, B.S. (Marquette), Ph.M., Ph.D. (Wisconsin), Assistant Professor of Zoology, *Dartmouth College, Hanover, N. H.*

Fraps, Richard Mason, B.S., Ph.D. (Chicago), Senior Physiologist, Bureau of Animal Industry, *U. S. Department of Agriculture, Beltsville, Md.*

Fraser, Charles McLean, A.B., A.M. (Toronto), Ph.D. (Iowa), LL.D. (British Columbia), F.R.S.C., Professor of Zoology, Emeritus, *University of British Columbia, Vancouver, British Columbia, Canada.*

Friedman, Moe Hegby Fred, B.Sc. (McGill), M.A. (Western Ontario), Ph.D. (McGill), Research Associate, *Wayne University, College of Medicine, 1512 St. Antoine St., Detroit, Mich.*

Friedmann, Herbert, B.Sc. (College of the City of New York), Ph.D. (Cornell), Curator, Division of Birds, *U. S. National Museum, Smithsonian Institution, Washington, D. C.*

Friend, Roger Boynton, B.S. (Mass. Agric.), Ph.D. (Yale), Entomologist, Connecticut Agricultural Experiment Station; Lecturer (Professorial rank) Forest Entomology, Yale University; *123 Huntington St., New Haven, Conn.*

Fries, Erik Fritiof Bjerkander, A.B., A.M., Ph.D. (Harvard), Assistant Professor of Biology, College of the City of New York, *248 West 17th St., New York, N. Y.* (On leave for military service, '42. Lt., U. S. N. R.) *South Brewster, Mass.*

Frisch, John A., S.J., A.B., M.A. (Woodstock), M.S. (Canisius), Ph.D. (Johns Hopkins), Professor of Biology, Head of the Department, *Canisius College, Buffalo, N. Y.*

FULTON, JOHN FARQUHAR, B.S., M.D. (Harvard), B.A., M.A., D.Phil. (Oxford), M.A. (Hon.) (Yale), LL.D. (Kenyon), D.Sc. (Hon.) (Oxford), Sterling Professor of Physiology, Yale University School of Medicine, *333 Cedar St., New Haven, Conn.*

FUNKHOUSER, WILLIAM DELBERT, A.B. (Wabash), M.A., Ph.D. (Cornell), Sc.D. (Wabash), Professor of Zoology and Dean, Graduate School, *University of Kentucky, Lexington, Ky.*

GAGE, SIMON HENRY, B.S. (Cornell), Professor of Histology and Embryology, Emeritus, *Stimson Hall, Cornell University, Ithaca, N. Y.*

GALTSOFF, PAUL S., Graduate (Moscow), Ph.D. (Columbia), Senior Biologist, *U. S. Fish and Wildlife Service, College Park, Md.*

GARDINER, MARY SUMMERFIELD, A.B., M.A., Ph.D. (Bryn Mawr), Associate Professor of Biology, Bryn Mawr College, *Dalton Hall, Bryn Mawr, Pa.*

GARMAN, HARRISON, D.Sc. (Kentucky), Professor of Entomology, Emeritus, and Head of the Department, University of Kentucky, *638 South Limestone St., Lexington, Ky.*

GATES, WILLIAM HAZEN, A.B. (Williams), D.Sc. (Harvard), Professor of Zoology and Entomology, *Louisiana State University, Baton Rouge 3, La.*

GAUNT, ROBERT, B.A. (Tulsa), M.A., Ph.D. (Princeton), Associate Professor of Biology, *New York University, Washington Square College, New York, N. Y.*

GEISER, SAMUEL WOOD, B.A., M.A. (Upper Iowa), Ph.D. (Johns Hopkins), Professor of Biology, *Southern Methodist University, Dallas, Texas.*

GEIMAN, QUENTIN MONROE, B.S. (Gettysburg College), M.S., Ph.D. (Pennsylvania), Instructor in Comparative Pathology and Tropical Medicine, *Harvard Medical School and School of Public Health, Boston, Mass.*

GEROULD, JOHN HIRAM, Litt.B. (Dartmouth), A.B., A.M., Ph.D. (Harvard), Professor of Zoology, Emeritus, Dartmouth College, *36 Occom Ridge, Hanover, N. H.*

GIESE, ARTHUR CHARLES, B.S. (Chicago), Ph.D. (Stanford), Associate Professor of Biology, *Stanford University, Calif.*

GILBERT, CHAUNCEY MCLEAN, B.S. (Massachusetts), Ph.D. (Virginia), Assistant Professor of Biology, University of Virginia, *3 Rugby Apartments, University Station, Charlottesville, Va.*

GILCHRIST, FRANCIS GARRITT, A.B., Ph.D. (California), *Riverside Junior College, Riverside, Calif.*

GLASER, OTTO CHARLES, A.B. (Johns Hopkins), A.M. (Amherst), Ph.D. (Johns Hopkins), Harkness Professor of Biology, *Amherst College, Amherst, Mass.*

GLASS, H(IRAM) BENTLEY, A.B., M.A. (Baylor), Ph.D. (Texas), Associate Professor of Biology, *Goucher College, Baltimore, Md.*

GLUECKSOHN-SCHOENHEIMER, SALOME, Ph.D. (Freiburg i. Br.), Research Associate, *Department of Zoology, Columbia University, New York, N. Y.*

GOLDFORB, A. J., B.S. (College of the City of New York), Ph.D. (Columbia), General Secretary and Editor in Chief, Proceedings Society for Experimental Biology and Medicine, Professor of Biology, *College of the City of New York, New York, N. Y.*

GOLDSCHMIDT, RICHARD B., Ph.D. (Heidelberg), M.D. (Kiel), Sc.D. (Madrid), Professor of Zoology, *Department of Zoology, University of California, Berkeley, Calif.*

Goldsmith, Eli D., B.S. (College of the City of New York), M.S. (New York), M.A., Ph.D. (Harvard), Instructor in Biology, *New York University, Washington Square College, New York, N. Y.*

Goldsmith, Joseph B(enjamin), A.B. (Southwestern), A.M. (Oklahoma), Ph.D. (Wisconsin), Associate Professor, Department of Histology and Embryology, *Oklahoma University School of Medicine, Oklahoma City, Okla.*

Goldsmith, William Marion, B.Pd., A.B. (Hillsdale), A.M., Ph.D. (Indiana), Instructor in Zoology, *Department of Zoology, University of Dubuque, Iowa.*

Goodale, Hubert Dana, Ph.D. (Columbia), Biologist, Mount Hope Farm, *257 W. Main St., Williamstown, Mass.*

Goodrich, Hubert Baker, B.S. (Amherst), M.A., Ph.D. (Columbia), Professor of Biology, *Wesleyan University, Middletown, Conn.*

Gorbman, Aubrey, A.B., M.S. (Wayne), Ph.D. (California), Instructor in Biology, *Department of Biology, Wayne University, Detroit, Mich.*

Gordon, Albert S(aul), B.S. (College of the City of New York), M.S., Ph.D. (New York), Instructor in General Physiology, *Department of Biology, Washington Square College, New York University, New York, N. Y.*

Gordon, Myron, B.S., Ph.D. (Cornell), Research Associate in Genetics of the New York Zoological Society, *American Museum of Natural History, New York, N. Y.*

Gowen, John Whittemore, B.S. (Maine), M.S., Ph.D. (Columbia), Professor of Genetics, *Iowa State College, Ames, Iowa.*

Graham, George Laurin, A.B. (Grand Island), M.S. (Kansas State), Sc.D. (Johns Hopkins), Associate, Department of Animal and Plant Pathology, *Rockefeller Institute for Medical Research, Princeton, N. J.*

Graham, John Young, Ph.D. (Munich), Professor of Biology, *University of Alabama, University, Ala.*

Grant, Madeleine Parker, S.B. (Simmons), A.M., Ph.D. (Radcliffe), Member of Science Faculty, *Sarah Lawrence College, Bronxville, N. Y.*

Graubard, Mark A., B.S. (College of the City of New York), M.A., Ph.D. (Columbia), Research Associate, *Department of Physiology, Clark University, Worcester, Mass.*

Grave, Caswell, B.S. (Earlham), Ph.D. (Johns Hopkins), Professor of Zoology, Emeritus, Washington University, St. Louis, *Winter Park, Fla.*

Gray, Irving E., B.S. (Massachusetts State), M.S., Ph.D. (Wisconsin), Professor of Zoology, *Duke University, Durham, N. C.*

Gray, James Clarke, A.B., M.A. (Syracuse), Ph.D. (Chicago), Associate Professor of Biology, *Western Reserve University, Cleveland, Ohio.*

Gray, Peter, Ph.D. (London), D.I.C. Professor of Biology, *University of Pittsburgh, Pittsburgh, Pa.*

Greep, Roy Orval, B.S. (Kansas State Agric. College), M.S., Ph.D. (Wisconsin), Research Associate, Pharmacology Division, *Squibb Institute for Medical Research, New Brunswick, N. J.*

Gregory, Louise Hoyt, A.B. (Vassar), A.M., Ph.D. (Columbia), Professor of Zoology and Associate Dean, *Barnard College, New York, N. Y.*

Griffen, Allen Beattie, B.A., Ph.D. (Texas), Associate Professor of Zoology, *Department of Zoology, University of Texas, Austin, Texas.*

GRIFFIN, LAWRENCE EDMONDS, A.B., Ph.B. (Hamline), Ph.D. (Johns Hopkins), Professor of Biology, *Reed College, Portland, Ore.*

GUDGER, E. W., B.S., M.S. (Nashville), Ph.D. (Johns Hopkins), *American Museum of Natural History, Department of Ichthyology, New York, N. Y.*

GULICK, ADDISON, A.B. (Oberlin), A.M. (Harvard), Ph.D. (Würzburg, Germany), Professor of Physiological Chemistry, University of Missouri, *308 Westmount Ave., Columbia, Mo.*

GUTHRIE, MARY JANE, A.B., A.M. (Missouri), Ph.D. (Bryn Mawr), Professor of Zoology, University of Missouri, *Lefevre Hall, University of Missouri, Columbia, Mo.*

GUYER, MICHAEL FREDERIC, B.S. (Chicago), A.M. (Nebraska), Ph.D. (Chicago), LL.D. (Missouri), Professor of Zoology, *Biology Building, University of Wisconsin, Madison, Wis.*

HADLEY, CHARLES ELMER, B.A. (Bates), M.A. (Trinity, Harvard), Ph.D. (Harvard), Associate Professor of Biology, *New Jersey State Teachers College, Upper Montclair, N. J.*

HAGUE, FLORENCE SANDER, B.A., M.A. (Kansas), Ph.D. (Illinois), Associate Professor of Biology, *Sweet Briar College, Sweet Briar, Va.*

HAHNERT, WILLIAM F(RANKLIN), A.B. (De Pauw), Ph.D. (Johns Hopkins), Associate Professor and Acting Head of the *Department of Zoology, Ohio Wesleyan University, Delaware, Ohio.*

HAIG, CHARLES, B.S., M.A., Ph.D. (Columbia), Assistant Professor of Physiology and Biochemistry, *New York Medical College, 5th Ave. and 106th St., New York, N. Y.*

HALL, EDMUND KENNARD, B.S. (Princeton), Ph.D. (Yale), D.Sc. (Brussels), Assistant Professor of Anatomy, School of Medicine, University of Louisville, *101 W. Chestnut St., Louisville, Ky.*

HALL, E(UGENE) RAYMOND, A.B. (Kansas), M.A., Ph.D. (California), Associate Professor of Vertebrate Zoology and Curator of Mammals, *Museum of Vertebrate Zoology, University of California, Berkeley, Calif.*

HALL, FRANK GREGORY, B.A. (Milton), M.A., Ph.D. (Wisconsin), Professor of Zoology, *Duke University, Durham, N. C.*

HALL, RICHARD P., A.B. (Henderson-Brown), A.M., Ph.D. (California), Professor of Biology, *New York University, University Heights, N. Y.*

HAMAKER, JOHN IRVIN, A.B. (Kansas), A.B., A.M., Ph.D. (Harvard), Professor of Biology, Randolph-Macon Woman's College, *16 N. Princeton St., Lynchburg, Va.*

HAMBURGER, VIKTOR, Ph.D. (Freiburg), Professor of Zoology, *Washington University, St. Louis, Mo.*

HAMILTON, HOWARD LAVERNE, B.A., M.S. (Iowa State, Ph.D. (Johns Hopkins), Capt., Sanitary Corps, Medical Research Officer, *Division of Virus and Rickettsial Diseases, Army Medical School, Army Medical Center, Washington 12, D. C.*

HAMILTON, WILLIAM JOHN, JR., B.S., M.S., Ph.D. (Cornell), Associate Professor of Zoology, *Cornell University, Ithaca, N. Y.* (On leave for military service, '43. Capt. Sanitary Corps, A. U. S.)

HAMLETT, GEORGE WHITFIELD DELUZ, B.A., M.A., Ph.D. (Texas), Agent, U. S. Biological Survey, *404 E. 20th St., Baltimore, Md.*

HAMMETT, FREDERICK SIMONDS, A.B. (Tufts), M.S. (Rhode Island State Agric.), A.M., Ph.D. (Harvard), Scientific Director, The Lankenau Hospital Research Institute, Philadelphia, Pa., *493 Commercial St., Provincetown, Mass.*

HAMRE, CHRISTOPHER JOHN, B.A. (St. Olaf), M.S., Ph.D. (Wisconsin), Professor of Zoology and Chairman of the Department, *University of Hawaii, Honolulu, Hawaii.*

HANCE, ROBERT THEODORE, A.B., M.A. (Cincinnati), Ph.D. (Pennsylvania), Professor of Biology; Director of Biological Research, *Duquesne University, Pittsburgh, Pa.*, Vice-President, in Charge of Research, *Rosco Laboratories, Inc., Blawnox, Pa.*

HANN, HARRY WILBUR, A.B. (Indiana), A.M., Ph.D. (Michigan), Assistant Professor of Zoology, *University of Michigan, Ann Arbor, Mich.*

HANSON, FRANK BLAIR, A.B. (George Washington), A.M. (Illinois), Ph.D. (American), Associate Director, Division of Natural Science, *Rockefeller Foundation, 49 W. 49th St., New York, N. Y.*

HARDESTY, MARY (Mrs. W. L. Duren, Jr.), B.A. (Tulane), M.S., Ph.D. (Chicago), Acting Instructor in Zoology, Tulane University, *3323 Joseph St., New Orleans, La.*

HARGITT, GEORGE THOMAS, Ph.B., Sc.D. (Syracuse), A.M. (Nebraska), Ph.D. (Harvard), Professor of Zoology, *Biology Building, Duke University, Durham, N. C.*

HARMAN, MARY THERESA, A.B., M.A., Ph.D. (Indiana), Professor of Zoology, *Kansas State College, Manhattan, Kan.*

HARRISON, ROSS GRANVILLE, Ph.D. (Johns Hopkins), M.D. (Bonn), Sc.D. (Cincinnati, Michigan, Dublin, Harvard, Yale, Columbia), Ph.D. (Freiburg), M.D. (Budapest), LL.D. (Johns Hopkins), Sterling Professor of Biology, Emeritus, Yale University; Chairman, National Research Council, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

HARTMAN, CARL G., Ph.D. (Texas), Professor of Zoology, Head of Department of Zoology and Physiology and Chairman of Biological Division, *University of Illinois, Urbana, Ill.*

HARTMAN, FRANK ALEXANDER, A.B., A.M. (Kansas), Ph.D. (Washington), Professor of Physiology, Chairman of Department of Physiology, *Hamilton Hall, Ohio State University, Columbus, Ohio.*

HARVEY, EDMUND NEWTON, Ph.D. (Columbia), Henry Fairfield Osborn Professor of Biology, *Princeton University, Princeton, N. J.*

HARVEY, ETHEL BROWNE, Ph.D. (Columbia), Princeton University, *48 Cleveland Lane, Princeton, N. J.*

HASKINS, CARYL PARKER, Ph.B. (Yale), Ph.D. (Harvard), Research Professor, Union College; Research Associate, Massachusetts Institute of Technology and Harvard University; Director, Haskins Laboratory, Schenectady, N. Y.; *1188 Avon Road, Schenectady, N. Y.*

HASLER, ARTHUR D., B.A. (Brigham Young), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Biology Building, University of Wisconsin, Madison, Wis.*

HATCH, MELVILLE HARRISON, A.B., M.A., Ph.D. (Michigan), Professor of Zoology, *University of Washington, Seattle, Wash.*

HATERIUS, HANS OLIVER, A.B. (Augustana), M.S., Ph.D. (Iowa), Professor of Physiology, *Wayne University, College of Medicine, 1512 St. Antoine St., Detroit, Mich.*

HATT, ROBERT T., B.S. (Michigan), M.A., Ph.D. (Columbia), Director, Cranbrook Institute of Science, *Bloomfield Hills, Mich.*

HAUSMAN, LEON AUGUSTUS, A.B., M.A., Ph.D. (Cornell), Professor of Zoology, *New Jersey College for Women (Rutgers University)*, and Consulting Ornithologist, *New Jersey State Experiment Station*, Lecturer in Ornithology, *New Jersey State College of Agriculture, New Brunswick, N. J. (Rutgers University.)*

HAYDEN, MARGARET ALGER, A.B., A.M., Ph.D. (Columbia), Professor of Zoology, *Wellesley College, Wellesley, Mass.*

HAYS, FRANK ALFRED, B.S. (Oklahoma), M.A. (Nebraska), Ph.D. (Iowa State), Research Professor in Poultry Investigations, *Massachusetts Agricultural Experiment Station, Amherst, Mass.*

HECHT, SELIG, B.S. (College of the City of New York), Ph.D. (Harvard), Professor of Biophysics, Columbia University, *35 Claremont Ave., New York, N. Y.*

HEILBRUNN, LEWIS VICTOR, A.B., Ph.D. (Chicago), Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

HELFF, OTTO MAXIMILIAN, B.S. (New Hampshire), M.S. (Chicago), Ph.D. (Yale), Associate Professor of Biology, *New York University, University Heights, New York, N. Y.*

HELLBAUM, ARTHUR ALFRED, B.A. (St. Olaf), M.A., Ph.D. (Wisconsin), Associate Professor of Physiology, *Oklahoma University, School of Medicine, Oklahoma City, Okla.*

HELWIG, EDWIN ROYER, A.B. (Western Maryland), Ph.D. (Pennsylvania), Assistant Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

HENSHAW, PAUL STEWART, A.B. (Southwestern College), M.S., Ph.D. (Wisconsin), Biophysicist at Memorial Hospital, *2 W. 106th St., New York, N. Y.*

HERRICK, CHARLES JUDSON, Ph.D. (Columbia), Professor of Neurology, Emeritus, The University of Chicago, *236 Morningside Drive, Grand Rapids 6, Mich.*

HERRICK, CHESTER ALBERN, B.S., M.S. (Kansas State College), Sc.D. (Johns Hopkins), Professor of Zoology and of Veterinary Science, *Department of Zoology, University of Wisconsin, Madison, Wis.*

HERRICK, EARL H., B.S., M.S. (Kansas State), Ph.D. (Harvard), Professor of Zoology and Experiment Station Mammalogist, *Department of Zoology, Kansas State College, Manhattan, Kan.*

HERSH, AMOS HENRY, A.B. (Franklin and Marshall), Ph.D. (Illinois), Associate Professor of Biology, *Western Reserve University, Cleveland, Ohio.*

HESS, WALTER NORTON, A.B. (Oberlin), A.M., Ph.D. (Cornell), Professor of Biology, *Department of Biology, Hamilton College, Clinton, N. Y.*

HIBBARD, HOPE, A.B., A.M. (Missouri), Ph.D. (Bryn Mawr), Sc.D. (Sorbonne), Professor of Zoology, *Oberlin College, Oberlin, Ohio.*

HIESTAND, WILLIAM ANDREW, B.A., M.A., Ph.D. (Wisconsin), Associate Professor of Physiology, Purdue University, *Hillcrest Rd., West Lafayette, Ind.*

HILE, RALPH, A.B. (Indiana Central), Ph.D. (Indiana), Associate Aquatic Biologist, U. S. Fish and Wildlife Service, *1027 University Museum, Ann Arbor, Mich.*

HILL, SAMUEL E., B.S. (Texas Christian), A.M., Ph.D. (Princeton), Professor of Biology, *Russell Sage College, Troy, N. Y.*

HILTON, WILLIAM ATWOOD, B.S., Ph.D. (Cornell), Professor of Zoology, Pomona College; Director Laguna Marine Biological Laboratory, Laguna Beach, Calif., *1263 Dartmouth St., Claremont, Calif.*

HINELINE, GERTRUDE WHITE, B.A. (Milwaukee-Downer), M.A., Ph.D. (Wisconsin), *425 Rich Ave., Mt. Vernon, N. Y.*

HINRICHS, MARIE AGNES, A.B. (Lake Forest), Ph.D. (Chicago), MD. (Rush), Professor of Physiology and Head of Student Health Service, *Southern Illinois Normal University, Carbondale, Ill.*

HISAW, FREDERICK LEE, A.B., B.S., A.M., LL.D. (Missouri), Ph.D. (Wisconsin), Professor of Zoology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

HITCHCOCK, FRED ANDREWS, M.S., Ph.D. (Ohio State), Associate Professor of Physiology, *Ohio State University, Columbus, Ohio.*

HOADLEY, LEIGH, A.B. (Michigan), Ph.D. (Chicago), Professor of Zoology, Biological Laboratories, *Harvard University, Cambridge, Mass.*

HOAGLAND, HUDSON, A.B. (Columbia), M.S. (Mass. Inst. Tech.), Ph.D. (Harvard), Professor of General Physiology, *Clark University, Worcester, Mass.*

HOBBS, ELIZABETH SANDERS, (MRS. JOSEPH R.), A.B. (Goucher), D.Sc. (Johns Hopkins), Assistant Professor of Zoology, *Smith College, Northampton, Mass.*

HODGE, CHARLES 4TH, A.B., Ph.D. (Pennsylvania), Assistant Professor, *Department of Biology, Temple University, Philadelphia, Pa.*

HOGUE, MARY JANE, A.B. (Goucher), Ph.D. (Würzburg), Associate in Anatomy, *University of Pennsylvania, School of Medicine, Philadelphia, Pa.*

HOLLANDER, WILLARD FISHER, B.A. (Texas), M.S., Ph.D. (Wisconsin), Research Associate, *Department of Genetics, Cold Spring Harbor, N. Y.*

HOLMES, SAMUEL JACKSON, B.S., M.S. (California), Ph.D. (Chicago), Professor of Zoology, *University of California, Berkeley, Calif.*

HOLMQUIST, ALBERT M., A.B. (St. Olaf), M.S., Ph.D. (Chicago), Professor of Biology, *St. Olaf College, Northfield, Minn.*

HOOKER, CHARLES WRIGHT, A.B., A.M., Ph.D. (Duke), Assistant Professor of Anatomy, *Yale University School of Medicine, New Haven, Conn.*

HOPKINS, DWIGHT LUCIAN, B.S., M.S. (Virginia), Ph.D. (Johns Hopkins), Professor of Zoology, *Mundelein College, Chicago, Ill.*

HOPKINS, HOYT S., A.B., A.M. (Oberlin), Ph.D. (Hopkins), Associate Professor of Physiology, New York University, College of Dentistry, *209 E. 23rd St., New York, N. Y.*

HOPKINS, SEWELL HEPBURN, B.S. (Williams and Mary), M.A., Ph.D. (Illinois), Associate Professor of Biology, *Department of Biology, A. and M. College, College Station, Texas.*

HOUSER, GILBERT LOGAN, B.S., M.S. (Iowa), Ph.D. (Johns Hopkins), Professor of Zoology, State University of Iowa, *430 Iowa Ave., Iowa City, Iowa.*

HOWLAND, RUTH B., Ph.M. (Syracuse), Ph.D. (Yale), Associate Professor of Biology, *Washington Square College, Washington Square East, New York, N. Y.*

HOY, WILLIAM E., A.B. (Franklin and Marshall), Ph.D. (Princeton), Professor of Biology and Head of the Department, *University of South Carolina, Columbia, S. C.*

HUBBS, CARL L(EAVITT), A.B., A.M. (Stanford), Ph.D. (Michigan), Curator of Fishes; Professor of Zoology; Research Associate in Laboratory of Vertebrate Biology; Honorary Research Associate in Institute for Fisheries Research, *University of Michigan Museum, Ann Arbor, Mich.*

HUESTIS, RALPH RUSKIN, B.S.A. (McGill), M.S., Ph.D. (California), Professor of Zoology, *University of Oregon, Eugene, Ore.*

HUETTNER, ALFRED F., A.B. (South Dakota), A.M., Ph.D. (Columbia), Associate Professor of Biology, *Queens College, Flushing, N. Y.*

HUGHES-SCHRADER, SALLY, B.S. (Grinnell), Ph.D. (Columbia), *Department of Zoology, Columbia University, New York, N. Y.*

HULL, FRANK MONTGOMERY, B.S. (Mississippi State College), M.S. (Ohio State), Ph.D. (Harvard), Professor of Zoology, *Department of Biology, University of Mississippi, University, Miss.*

HUMPHREY, RUFUS RICHARD, A.B. (Michigan State Normal), A.M., Ph.D. (Cornell), Professor of Anatomy, *University of Buffalo, 24 High St., Buffalo, N. Y.*

HUNGATE, ROBERT EDWARD, A.B., Ph.D. (Stanford), Associate Professor of Zoology, and Research Biologist, The Biochemical Institute, *Department of Zoology and Physiology, The University of Texas, Austin, Texas.*

HUNT, HARRISON RANDALL, B.S. (Allegheny), M.A., Ph.D. (Harvard), Head of the Department of Zoology and Zoologist in the Agricultural Experiment Station, Michigan State College, East Lansing, Mich., *R.D. No. 1, East Lansing, Mich.*

HUNT, THOMAS ELWOOD, A.B. (Earlham), Ph.D. (Chicago), Associate Professor of Histology and Embryology, *University of Alabama School of Medicine, University, Ala.*

HUNTER, FRANCIS ROBERT, B.S. (California Institute of Technology), M.A. (Wesleyan), Ph.D. (Princeton), Instructor in Zoology, *Department of Zoology, Rhode Island State College, Kingston, R. I.*

HUNTER, GEORGE WILLIAM, A.B., A.M. (Williams), Ph.D. (New York), Lecturer in Methods of Science Education, *Claremont Colleges, Claremont, Calif.*

HUNTER, GEORGE WILLIAM, III, B.S. (Knox), M.S., Ph.D. (Illinois), Major, Sn.C., A.U.S. Division of Parasitology and Tropical Medicine, *Army Medical School, Army Medical Center, Washington 12, D. C.*

HUNTSMAN, ARCHIBALD GOWANLOCK, B.A., M.D. (Toronto), F.R.S.C. (Canada), Professor of Marine Biology, Editor and Consulting Director, Fisheries Research Board of Canada, *University of Toronto, Toronto, Canada.*

HURST, CLARENCE THOMAS, A.B., A.M. (Western State College of Colo.), Ph.D. (California), Professor of Zoology and Dean of the Graduate School, *Western State College of Colorado, Gunnison, Colo.*

HUSSAKOF, LOUIS, B.S. (College of the City of New York), Ph.D. (Columbia), Research Associate, Department of Ichthyology, *American Museum of Natural History, 77th St. and Central Park West, New York, N. Y.*

HUTCHINSON, CRANFORD, A.B. (Ohio Wesleyan), Ph.D. (Yale), Instructor in Anatomy, *Jefferson Medical College, Philadelphia, Pa.*

HUTCHINSON, G(EORGE) EVELYN, B.A., M.A. (Cambridge), Associate Professor of Zoology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

HUTT, FREDERICK BRUCE, B.S.A. (Toronto), M.S. (Wisconsin), M.A. (Manitoba), Ph.D., D.Sc. (Edinburgh), Professor of Zoology, *Cornell University, Ithaca, N. Y.*

HYMAN, LIBBIE HENRIETTA, B.S., Ph.D., Sc.D. (Chicago), Research Associate, Department of Invertebrates, *American Museum of Natural History, New York, N. Y.*

IBSEN, HEMAN LAURITZ, B.S., M.S., Ph.D. (Wisconsin), Professor of Genetics, Department of Animal Husbandry, *Kansas State College, Manhattan, Kan.*

ILLICK, JOHN THERON, A.B., A.M. (Syracuse), Ph.D. (Princeton), Associate Professor of Zoology, *Lyman Hall, Syracuse University, Syracuse, N. Y.*

INGLES, LLOYD GLENN, A.B. (Redlands), M.A. (Claremont), Ph.D. (California), Professor of Biology, *Chico State College, Chico, Calif.*

IRVING, LAURENCE, A.B. (Bowdoin), A.M. (Harvard), Ph.D. (Stanford), Professor of Biology and Chairman of the Department of Zoology, *Swarthmore College, Swarthmore, Pa.*

IRWIN, MALCOLM ROBERT, B.S., M.S., Ph.D. (Iowa State College), Professor of Genetics, *Department of Genetics, University of Wisconsin, Madison, Wis.*

ISELY, FREDERICK B., B.S. (Wichita), M.S. (Chicago), Professor of Biology, *Trinity University, San Antonio, Texas.*

JACOBS, MERKEL HENRY, A.B., Ph.D. (Pennsylvania), Professor of General Physiology, *University of Pennsylvania, Philadelphia, Pa.*

JAHN, THEODORE LOUIS, B.A. (Rice Institute), M.Sc., Ph.D. (New York), Associate Professor, Department of Zoology, *State University of Iowa, Iowa City, Iowa.*

JANES, RALPH GORDON, A.B. (Battle Creek), M.S., Ph.D. (New York), Assistant Professor of Anatomy, Wayne University, College of Medicine, *1512 St. Antoine St., Detroit, Mich.*

JEFFERS, KATHARINE R., A.B., A.M. (Missouri), Ph.D. (Bryn Mawr), Assistant Professor of Zoology, *Duke University, Durham, N. C.*

JENNINGS, HERBERT SPENCER, B.S. (Michigan), A.M., Ph.D. (Harvard), LL.D. (Clark, Pennsylvania), Sc.D. (Michigan, Chicago), LL.D. (California), Sc.D. (Oberlin), Professor of Zoology, Emeritus, The Johns Hopkins University, *Department of Zoology, University of California, Los Angeles, Calif.*

JEWELL, MINNA ERNESTINE. A.B. (Colorado), A.M., Ph.D. (Illinois), Department of Biology, *Thornton Junior College, Harvey, Ill.*

JOB, THESLE T., A.B. (Simpson), M.S., Ph.D. (Iowa), Professor of Anatomy, Loyola University School of Medicine, *706 S. Wolcott St., Chicago, Ill.*

JOHANNSEN, OSKAR AUGUSTUS, B.S. (Illinois), A.M., Ph.D. (Cornell), Professor of Entomology, Emeritus, College of Agriculture, *Cornell University, Ithaca, N. Y.*

JOHNSON, FRANK HARRIS, A.B. (Princeton), A.M. (Duke), Ph.D. (Princeton), Assistant Professor of Biology, *Department of Biology, Princeton University, Princeton, N. J.*

JOHNSON, HENRY HERBERT, B.S. (Mercer), A.M., Ph.D. (Columbia), Associate Professor of Biology, *Department of Biology, College of the City of New York, New York, N. Y.*

Johnson, Percy Leroy, B.S. (Maine), M.S. (Syracuse), Ph.D. (Johns Hopkins), Professor of Biology, *Missouri Valley College, Marshall, Mo.*

Johnson, Willis Hugh, A.B. (Wabash), M.S., Ph.D. (Chicago), Professor of Biology, Stanford University, *2421 Ramona St., Palo Alto, Calif.*

Jones, E. Elizabeth, A.B., Ph.D. (Radcliffe), A.M. (Maine), Associate Professor of Zoology, *Wellesley College, Wellesley, Mass.*

Jones, E(dmund) Ruffin, Jr., B.A., B.S., M.A., Ph.D. (Virginia), Professor of Biology, *College of William and Mary, Norfolk Division, Norfolk, Va.*

Jones, Sarah Von Hoosen, Ph.B. (Chicago), M.S., Ph.D. (Wisconsin), *Rochester, Mich.*

Jordan, Harvey Ernest, B.A., M.A., Sc.D. (Hon.) (Lehigh), Ph.D. (Princeton), Professor of Anatomy and Director of the Anatomical Laboratories; Dean, Department of Medicine, *Pavilion 8, East Lawn, University of Virginia, University, Va.*

Juday, Chancey, A.B., A.M., LL.D. (Indiana), Professor of Limnology, Emeritus, *Biology Building, University of Wisconsin, Madison, Wis.*

Juhn, Mary, Ph.D. (Zurich), Research Associate Professor, *Poultry Department, University of Maryland, College Park, Md.*

Kaston, B(enjamin) J(ulian), B.S. (North Carolina State College), Ph.D. (Yale), Professor of Biology, *Brenau College, Gainesville, Ga.* (On leave for military service, '43.)

Kater, John McAllister, B.S. (Virginia), M.A. (Princeton), Ph.D. (California), Director of Laboratories, *Walker Vitamin Products, Inc., Mt. Vernon, N. Y.*

Kaufmann, Berwind P(etersen), B.S., M.A., Ph.D. (Pennsylvania), Resident Investigator, Department of Genetics, *Carnegie Institution of Washington, Cold Spring Harbor, N. Y.*

Keeler, Clyde Edgar, B.S., M.S. (Denison), M.A., D.Sc. (Harvard), Instructor in Anatomy, Harvard Medical School, *Shattuck St., Boston, Mass.* (On leave for military service, '43.)

Kempton, Rudolf T., B.S. (Bates), M.A. (Columbia), Ph.D. (New York), Professor of Zoology, Chairman of the Department of Zoology, and Curator of the Natural History Museum, *Vassar College, Poughkeepsie, N. Y.*

Kendall, James I., B.S. (New York), M.S., Ph.D. (Harvard), D.Sc. (Sofia), Assistant Professor of Biology, College of the City of New York, *P.O. 14, Tenafly, N. J.*

Kendeigh, S. Charles, A.B., A.M. (Oberlin), Ph.D. (Illinois), Associate Professor of Zoology, University of Illinois, Vivarium Building, *Wright and Healey Sts., Champaign, Ill.*

Kenk, Roman, Ph.D. (Graz, Austria), Associate Professor of Biology, *Department of Biology, University of Puerto Rico, Rio Piedras, Puerto Rico.*

Kepner, William Allison, A.B., A.M. (Franklin and Marshall), Ph.D. (Virginia), Sc.D. (Franklin and Marshall), Professor of Biology, University of Virginia, *29 University Place, University, Va.*

Kidder, George Wallace, A.B. (Oregon), M.A. (California), Ph.D. (Columbia), Assistant Professor of Biology, *Brown University, Providence, R. I.*

Kille, Frank Ralph, B.S. (College of Wooster), S.M., Ph.D. (Chicago), Associate Professor of Zoology, *Edward Martin Biological Laboratory, Swarthmore College, Swarthmore, Pa.*

KIMBALL, RICHARD F., A.B., Ph.D. (Johns Hopkins), Associate in Zoology, *Department of Biology, The Johns Hopkins University, Homewood, Baltimore 18, Md.*

KINDRED, JAMES ERNEST, A.B. (Tufts), A.M., Ph.D. (Illinois), Professor of Anatomy, Medical School, *University of Virginia, Box 1341, University, Va.*

KING, HELEN DEAN, A.B. (Vassar), A.M., Ph.D. (Bryn Mawr), Member of The Wistar Institute of Anatomy and Biology, *The Wistar Institute, 36th St. and Woodland Ave., Philadelphia, Pa.*

KING, ROBERT LESLIE, A.B., Ph.D. (Pennsylvania), Professor of Zoology, *University of Iowa, Iowa City, Iowa.*

KINSEY, ALFRED CHARLES, B.S. (Bowdoin), Sc.D. (Harvard), Professor of Zoology, *Indiana University, Bloomington, Ind.*

KIRBY, HAROLD, B.S. (Emory), M.A., Ph.D. (California), Professor of Zoology, *University of California, Berkeley, Calif.*

KIRKHAM, WILLIAM BARRI, B.A., M.A., Ph.D. (Yale), Consulting Director, Museum of Natural History, *220 State St., Springfield, Mass.*

KLEINHOLZ, LEWIS HERMANN, B.S. (Colby), M.A., Ph.D. (Harvard), Instructor in Biology, *Cambridge Junior College, Harvard Biological Laboratories, Cambridge, Mass.*

KOFOID, CHARLES ATWOOD, A.B., Sc.D. (Hon.) (Oberlin), A.M., Ph.D. (Harvard), D.Sc. (Hon.) (Wales), LL.D. (Hon.) (California), Professor of Zoology, Emeritus, *University of California, Berkeley, Calif.*

KOPAC, M(ILAN) J(AMES), B.S., M.S. (Nebraska), Ph.D. (California), Visiting Assistant Professor of Biology, *Washington Square College, New York University, New York, N. Y.*

KOPPÁNYI, THEODORE, Ph.D. (Vienna), Professor of Pharmacology, Georgetown University, School of Medicine, *3900 Reservoir Road, Washington, D. C.*

KORNHAUSER, SIDNEY ISAAC, A.B. (Pittsburgh), A.M., Ph.D. (Harvard), Professor of Anatomy and Executive Secretary, School of Medicine, University of Louisville, *101 W. Chestnut St., Louisville, Ky.*

KRECKER, FREDERICK HARTZLER, A.B., Ph.D. (Princeton), A.M. (Cornell), Professor of Zoology, *Ohio University, Athens, Ohio.*

KROC, ROBERT LOUIS, B.A., M.A. (Oberlin), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Department of Zoology, Indiana University, Bloomington, Ind.*

KROPP, BENJAMIN, S.B., A.M., Ph.D. (Harvard), Assistant Professor of Embryology, *Queen's University Medical School, Kingston, Ontario, Canada.*

KUDO, R. R., D.Sc. (Tokio Imperial University), Associate Professor of Zoology, Department of Zoology, *322 Natural History Building, University of Illinois, Urbana, Ill.*

KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D. (Yale), Professor of Biology, *Lafayette College, Easton, Pa.*

KUNTZ, ALBERT, B.A., (Morningside), Ph.D. (State University of Iowa), M.D. (St. Louis University School of Medicine), Professor of Microanatomy, *St. Louis University School of Medicine, 1402 S. Grand Blvd., St. Louis, Mo.*

LAMBERT, WILLIAM VINCENT, B.S. (Nebraska), M.S. (Kansas State), Ph.D. (California), Associate Director, *Agricultural Experiment Station, Purdue University, Lafayette, Ind.*

Lamoreux, Welford Forrest, B.S. (Iowa State), M.S., Ph.D. (Cornell), Geneticist and Director of Research, *Kimber Poultry Breeding Farm, Niles, Calif.*

Landauer, Walter, Ph.D.Nat. (Heidelberg), Professor of Genetics, *Storrs Agricultural Experiment Station, Storrs, Conn.*

Langlois, Thomas Huxley, B.S., M.S. (Michigan), Ph.D. (Ohio State), Professor of Zoology and Director, Franz Theodore Stone Laboratory, Ohio State University, *Put-in-Bay, Ohio.*

La Rue, George R., B.S. (Doane), A.M. (Nebraska), Ph.D. (Illinois), Professor of Zoölogy, *University of Michigan, Ann Arbor, Mich.*

Lashley, Karl Spencer, A.B. (West Virginia), M.S. (Pittsburgh), Ph.D. (Johns Hopkins), Sc.D. (Pittsburgh, Chicago), Research Professor of Neuropsychology, Harvard University; Director, Yerkes Laboratories of Primate Biology, *Orange Park, Fla.*

Latimer, Homer Barker, A.B., A.M., Ph.D. (Minnesota), Professor of Anatomy, *University of Kansas, Lawrence, Kan.*

Lawson, Chester Alvin, B.S. (Thiel), M.S., Ph.D. (Michigan), Michigan State College, *East Lansing, Mich.*

Leathem, James Hain, B.S. (Lebanon Valley), M.A., Ph.D. (Princeton), Assistant Professor of Zoology, *Department of Zoology, Rutgers University, New Brunswick, N. J.*

Leonard, Samuel L(eeson), B.S. (Rutgers), M.S., Ph.D. (Wisconsin), Associate Professor of Zoology, Cornell University, *Ithaca, N. Y.*

Lerner, I. Michael, B.S.A., M.S.A. (British Columbia), Ph.D. (California), Assistant Professor of Poultry Husbandry, *Division of Poultry Husbandry, University of California, Berkeley, Calif.*

LeVeque, Norma, B.A. (Colorado), M.A. (California), Ph.D. (Colorado), Assistant Professor of Biology, University of Colorado, *2135 4th St., Boulder, Colo.*

Levine, Pincus Philip, B.S. (College of the City of New York), D.V.M. (New York State Veterinary College), M.S., Ph.D. (Cornell), Associate Professor of Pathology and Bacteriology, *New York State Veterinary College, Ithaca, N. Y.*

Lewis, Frederic Thomas, A.M., M.D. (Harvard), James Stillman Professor of Comparative Anatomy, Emeritus, *Harvard Medical School, Boston, Mass.*

Liebmann, Emil, Ph.D. (Vienna), Research Fellow in Biology, *Department of Biology, Princeton University, Princeton, N. J.*

Light, Sol Felty, A.B. (Park), M.A. (Philippines), M.S. (Princeton), Ph.D. (California), Professor of Zoology, *University of California, 4047 Life Sciences Building, Berkeley, Calif.*

Lillie, Frank Rattray, B.A., Sc.D. (Toronto), Ph.D. (Chicago), Sc.D. (Yale, Harvard), LL.D. (Johns Hopkins), Andrew MacLeish Distinguished Service Professor of Embryology, Emeritus, The University of Chicago, *5801 Kenwood Ave., Chicago 37, Ill.*

Lillie, Ralph Stayner, A.B., Sc.D. (Toronto), Ph.D. (Chicago), Professor of General Physiology, Emeritus, *The University of Chicago, Chicago 37, Ill.*

Lindeman, Verlus Frank, B.A. (North-Central), M.S., Ph.D. (Iowa), Associate Professor of Zoology, Syracuse University, *12 Lyman Hall, Syracuse University, Syracuse, N. Y.*

Lindsey, Arthur Ward, A.B. (Morningside), M.S., Ph.D. (State University of Iowa), Professor of Zoology, Denison University, *P. O. Box 612, Granville, Ohio.*

Lineburg, Bruce, A.B. (Ohio), A.M., Ph.D. (Johns Hopkins), Professor of Biology, *Lake Forest College, Lake Forest, Ill.*

Little, Clarence Cook, A.B., S.M., Sc.D. (Harvard), LL.D. (New Hampshire, Albion, New Mexico, Colby), Litt.D. (Maine), Director, *Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.*

Litwiller, Raymond, B.A. (Goshen College), Ph.D. (Chicago), Wilson Junior College, *2024 S. Western Ave., Chicago, Ill.*

Loefer, John B., B.A. (Lawrence), M.S., Ph.D. (New York), Associate Professor of Biology and Chemistry, *Berea College, Berea, Ky.*

Long, Joseph Abraham, S.B., A.M., Ph.D. (Harvard), Professor of Embryology, *3075 Life Sciences Building, University of California, Berkeley, Calif.*

Loosanoff, Victor L., B.S. (Washington), Ph.D. (Yale), Director, *U. S. Fish and Wildlife Service Laboratory, Milford, Conn.*

Lucas, Alfred Martin, A.B. (Wabash), Ph.D. (Washington University), Associate Professor of Zoology, *Department of Zoology, Iowa State College, Ames, Iowa.*

Lucas, Miriam Scott (Mrs. A. M.), B.S., Ph.D. (Pennsylvania), *Department of Zoology, Iowa State College, Ames, Iowa.*

Luce, Wilbur Marshall, B.S. (Bates), M.S., Ph.D. (Illinois), Assistant Professor of Zoology, University of Illinois, *345 Natural History Building, Urbana, Ill.*

Ludwig, Daniel, A.B. (Ursinus), Ph.D. (Pennsylvania), Associate Professor of Biology, *New York University, University Heights, N. Y.*

Lumer, Hyman, B.A., M.A., Ph.D. (Western Reserve), Associate Professor of Biology, Fenn College, *2200 Prospect Ave., Cleveland, Ohio.*

Lund, Elmer Julius, Ph.D. (Johns Hopkins), Professor of Physiology and Biophysics, *University of Texas, Austin, Texas.*

Lund, Everett Eugene, B.S. (Iowa State College), M.A., Ph.D. (California), Associate Professor of Biology, *Department of Biology, Alfred University, Alfred, N. Y.*

Lutz, Brenton Reid, B.S., A.M., Ph.D. (Boston), Professor of Biology, *Boston University, 688 Boylston St., Boston, Mass.*

Lutz, Frank E., A.B. (Haverford), A.M., Ph.D. (Chicago), Curator of Insects and Spiders, *American Museum of Natural History, 77th St. and Central Park West, New York, N. Y.*

Luyet, Basile Joseph, A.B. (Fribourg), L.Sc., D.Sc. (Biology), D.Sc. (Physics), (Geneva), Professor of Biology, *St. Louis University Medical School, St. Louis, Mo.*

Lynch, Clara J., A.B. (Smith), A.M., Ph.D. (Columbia), Associate, Rockefeller Institute, *66th St. and York Ave., New York, N. Y.*

Lynch, James Eric, A.B., A.M. (Nebraska), Ph.D. (California), Professor, *School of Fisheries, University of Washington, Seattle, Wash.*

Lynch, Ruth Stocking (Mrs. Vernon Lynch), A.B. (Goucher), Ph.D. (Johns Hopkins), Chairman, Science Division, Maryland State Teachers College, *1121 Overbrook Road, Idlewyld, Baltimore 12, Md.*

LYNN, WILLIAM GARDNER, A.B., Ph.D. (Johns Hopkins), Associate Professor of Biology, *Department of Biology, The Catholic University of America, Washington, D. C.*

MACARTHUR, JOHN WOOD, A.B. (Oberlin), M.A. (Wabash), Ph.D. (Chicago), F.R.S.C., Associate Professor of Genetics, University of Toronto, *Department of Biology, University of Toronto, Toronto, Ontario, Canada.*

MACDOUGALL, MARY STUART, A.B. (Randolph-Macon), M.S. (Chicago), Ph.D. (Columbia), Sc.D. (Montpellier), Head of Biology Department and Professor of Zoology, *Agnes Scott College, Decatur, Ga.*

MACDOWELL, EDWIN CARLETON, A.B. (Swarthmore), S.M., Sc.D. (Harvard), Resident Investigator, Station for Experimental Evolution, *Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

MACLENNAN, RONALD FRASER, A.B. (Oberlin), A.M., Ph.D. (California), Assistant Professor of Zoology, *A. A. Wright Zoological Laboratory, Oberlin College, Oberlin, Ohio.*

MCCAY, CLIVE MAINE, A.B. (Illinois), M.S. (Iowa State), Ph.D. (California), Director of Nutrition Research, *Naval Medical Research Inst., Bethesda, Md.*

MCCLUNG, C. E., Ph.G., A.B., A.M., Ph.D. (Kansas), Sc.D. (Pennsylvania, Franklin and Marshall), Professor of Zoology, Emeritus, University of Pennsylvania, Professor of Zoology and Acting Head of the Department of Zoology, *Swarthmore College, Swarthmore, Pa.*

MCCLURE, CHARLES F. W., A.B., A.M. (Princeton), D.Sc. (Hon.) (Columbia), Professor of Comparative Anatomy, Emeritus, *Princeton University, Princeton, N. J.*

MCCULLOCH, IRENE, A.B., A.M. (Kansas), Ph.D. (California), Professor of Zoology, Allan Hancock Foundation, University of Southern California, *Los Angeles, Calif.*

MCCUTCHEON, FREDERICK HAROLD, Ph.D. (Duke), Associate Professor of Zoology, *North Carolina State College, Raleigh, N. C.*

MCEWEN, ROBERT STANLEY, A.B., A.M. (Western Reserve), Ph.D. (Columbia), Professor of Zoology, *Oberlin College, Oberlin, Ohio.*

MCGREGOR, JAMES HOWARD, B.S. (Ohio State), M.A., Ph.D. (Columbia), Professor of Zoology, Emeritus, *Columbia University, New York, N. Y.*

MCINDOO, NORMAN EUGENE, A.B., A.M. (Indiana), Ph.D. (Pennsylvania), Senior Entomologist, Bureau of Entomology, *7225 Blair Road, Takoma Park, Washington, D. C.*

MAGATH, THOMAS BYRD, Ph.B. (Emory), M.S. (Millikin), Ph.D., M.D. (Illinois), Professor of Pathology and Parasitology, University of Minnesota, and Consulting Physician, *Mayo Clinic, Rochester, Minn.*

MALUF, N(OBLE) S(UYDAM) RUSTUM, B.Sc. (American University, Cairo), M.S., Ph.D. (Cornell), Instructor in Physiology, *School of Medicine, Georgetown University, Washington, D. C.* (On leave for military service, '43, *427 Vanderbilt Hall, Harvard Medical School, Boston, Mass.*)

MANTER, HAROLD WINFRED, A.B. (Bates), A.M., Ph.D. (Illinois), Professor of Zoology, University of Nebraska, *204 Bessey Hall, University of Nebraska, Lincoln, Nebr.*

MANWELL, REGINALD DICKINSON, A.B., A.M. (Amherst), D.Sc. (Johns Hopkins), Professor of Zoology, Syracuse University, *25 Lyman Hall, Syracuse University, Syracuse, N. Y.* (On leave for military service, '43, 1st Lt. Sanitary Corps.)

†Mark, Edward L., A.B. (Michigan), Ph.D. (Leipzig), LL.D. (Michigan), LL.D. (Wisconsin), Hersey Professor of Anatomy, Emeritus, Harvard University, *109 Irving St., Cambridge, Mass.*

Marsh, Gordon, A.B., A.M., Ph.D. (Texas), Assistant Professor of Zoology, *Department of Zoology, State University of Iowa, Iowa City, Iowa.*

Marshall, Ruth, B.S., M.S. (Wisconsin), Ph.D. (Nebraska), Professor of Zoology, Emeritus, Rockford College, Rockford, Ill., *Wisconsin Dells, Wis.*

Marshall, William Stanley, B.S. (Swarthmore), Ph.D. (Leipzig), Professor of Entomology, Emeritus, University of Wisconsin, *139 E. Gilman St., Madison, Wis.*

Marsland, Douglas A., B.S. (New York), M.A. (Columbia), Ph.D. (New York), Associate Professor of Biology, *Department of Biology, New York University, Washington Square, New York, N. Y.*

Martin, Walter Edwin, B.Educ. (North Illinois State Teachers), M.S., Ph.D. (Purdue), Associate Professor of Zoology, DePauw University, *R.R. 4, Greencastle, Ind.*

Mast, Samuel Ottmar, B.S. (Michigan), Ph.D. (Harvard), M.Pd. (Michigan Normal), Sc.D. (Michigan), Professor of Zoology, Emeritus, *The Johns Hopkins University, Baltimore, Md.*

Matthews, Samuel A., B.S., M.A. (Boston), Ph.D. (Harvard), Professor of Biology, *Williams College, Williamstown, Mass.*

Mattox, Norman Thomas, A.B. (Miami), M.S., Ph.D. (Illinois), *Department of Zoology, Miami University, Oxford, Ohio.*

Mavor, James Watt, B.A. (Cantab.), Ph.D. (Harvard), Professor of Biology and Head of the Department, *Union College, Schenectady, N. Y.*

May, Raoul Michel, A.B. (Leland Stanford), A.M., Ph.D. (Harvard), Docteur ès Sciences, M.D. (Paris); Chef de Travaux, *Laboratoire d'Anatomie et d'Histologie Comparées, Sorbonne, Paris 5ᵉ, France.*

Mayr, Ernst, Ph.D. (Berlin), Associate Curator, Whitney-Rothschild Collection, *American Museum of Natural History, New York 24, N. Y.*

Mazia, Daniel, A.B., Ph.D. (Pennsylvania), Associate Professor of Zoology, *Department of Zoology, University of Missouri, Columbia, Mo.* (On leave for military service, '42. 1st Lt., U. S. A.)

Mead, Albert Davis, A.B. (Middlebury), A.M. (Brown), Ph.D. (Chicago), Sc.D. (Pittsburgh, Middlebury, Rhode Island State College), LL.D. (Brown), Professor of Biology, Emeritus, Brown University, *283 Wayland Ave., Providence, R. I.*

Melampy, Robert M., B.S. (Wilmington College), M.A. (Haverford), Ph.D. (Cornell), Associate Professor of Zoology, *Louisiana State University, Baton Rouge, La.*

Melander, A(xel) L(eonard), B.S., M.S. (Texas), Sc.D. (Harvard), Professor of Biology and Chairman of the Department, City College, *College of the City of New York, New York, N. Y.* (On leave for military service, '43. *4670 Rufedoux Lane, Riverside, Calif.*)

Mendoza, Guillermo, B.S., M.S., Ph.D. (Northwestern), Associate Professor of Zoology, *Department of Zoology, Grinnell College, Grinnell, Iowa.*

Merriman, Daniel, B.S., M.S. (Washington), Ph.D. (Yale), Assistant Professor of Biology, Director of the Bingham Oceanographic Laboratory, *Yale University, New Haven, Conn.*

Metz, Charles William, B.A. (Pomona), Ph.D. (Columbia), Professor of Zoology, *Zoological Laboratory, University of Pennsylvania, Philadelphia, Pa.*

Meyer, A(rthur) W(illiam), B.S. (Wisconsin), M.D. (Johns Hopkins), Professor of Anatomy, Emeritus, Stanford University, *121 Waverly St., Palo Alto, Calif.*

Meyer, Roland Kenneth, A.B. (Milton), A.M., Ph.D. (Wisconsin), Professor of Zoology, *Department of Zoology, University of Wisconsin, Madison, Wis.*

Mickey, George H(enry), A.B. (Baylor), M.S. (Oklahoma), Ph.D. (Texas), Assistant Professor of Zoology, *Department of Zoology, Louisiana State University, Baton Rouge, La.*

Middleton, Austin Ralph, A.B., Ph.D. (Johns Hopkins), Professor of Zoology, Director of Department of Biology, *University of Louisville, 1st and Chestnut Sts., Louisville, Ky.*

Miller, Alden Holmes, A.B., M.A., Ph.D. (California), Associate Professor of Zoology and Director, *Museum of Vertebrate Zoology, University of California, Berkeley, Calif.*

Miller, Harry M(ilton), Jr., B.S. (Ohio Wesleyan), Ph.D. (Illinois), Assistant Director, Division of Natural Sciences, *Rockefeller Foundation, 20 rue de la Baume, Paris, France.*

Miller, James Albert, A.B. (Wooster), Ph.D. (Chicago), Assistant Professor of Histology and Embryology, *Division of Anatomy, College of Medicine, University of Tennessee, Memphis, Tenn.*

Miller, John A(llen), B.A. (Ashland), M.S., Ph.D. (Ohio State), Assistant Professor, *Ohio State University, Columbus, Ohio.*

Miller, Robert Cunningham, A.B. (Greenville), M.A., Ph.D. (California), Director, *California Academy of Sciences, San Francisco, Calif.*

Milne, Lorus Johnson, B.A. (Toronto), M.A., Ph.D. (Harvard), Research Associate in Medical Physics, *Johnson Foundation, University of Pennsylvania, Philadelphia, Pa.*

Minnich, Dwight Elmer, A.B. (Miami), Ph.D. (Harvard), Professor of Zoology and Chairman of the Department, *University of Minnesota, Minneapolis, Minn.*

Moore, Carl R., B.S., A.M. (Drury), Ph.D. (Chicago), Professor of Zoology and Chairman of the Department, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

Moore, John Alexander, A.B., M.A., Ph.D. (Columbia), Instructor in Biology, *Queens College, Flushing, N. Y.*

* Moore, J. Percy, Ph.D. (Pennsylvania), Professor of Zoology, Emeritus, *University of Pennsylvania, Philadelphia, Pa.*

Morgan, Ann Haven, A.B., Ph.D. (Cornell), Professor of Zoology, *Mt. Holyoke College, South Hadley, Mass.*

†Morgan, Thomas Hunt, B.S. (Kentucky), Ph.D. (Johns Hopkins), Professor of Biology, Emeritus in residence, *California Institute of Technology, Pasadena, Calif.*

MORGAN, WILLIAM PITT, A.B. (Indiana Central), A.M., Ph.D. (Indiana), Professor of Biology, Indiana Central College, *Route 6, Box 414, Indianapolis, Ind.*

MORRILL, CHARLES V., A.M., Ph.D. (Columbia), Associate Professor of Anatomy, Cornell University Medical College, *1300 York Ave., New York, N. Y.*

MOSHER, EDNA, B.S. (Cornell), Ph.D. (Illinois), Professor of Biology, Emeritus, Adelphi College, Garden City, N. Y. *R. R. no. 1, Newport, Nova Scotia.*

MOSSMAN, HARLAND WINFIELD, B.S. (Allegheny), M.S., Ph.D. (Wisconsin), Associate Professor of Anatomy, *University of Wisconsin, Madison, Wis.*

MULLER, HERMANN J., A.B., A.M., Ph.D. (Columbia), D.Sc. (Edinburgh), Professor of Biology, Amherst College, *62 Gray St., Amherst, Mass.*

MURRAY, MARGARET RANSONE, A.B. (Goucher), M.S. (Washington), Ph.D. (Chicago), Research Assistant in Surgery, *College of Physicians and Surgeons, Columbia University, 630 W. 168th St., New York, N. Y.*

MYERS, EARL HAMLET, B.S. (Washington State College), Ph.D. (California), *308 Oceanographic Laboratory, Woods Hole, Mass.*

MYERS, GEORGE SPRAGUE, A.B., A.M., Ph.D. (Stanford), Professor of Biology, *Stanford University, Palo Alto, Calif.*

NABOURS, ROBERT K., Ph.D. (Chicago), Professor of Zoology and Experiment Station Zoologist, *Kansas State College, Manhattan, Kan.*

NABRIT, SAMUEL MILTON, B.S. (Morehouse), M.S., Ph.D. (Brown), Professor of Biology, *Atlanta University, Atlanta, Ga.*

NELSEN, OLIN EVERETT, A.M. (Brown), Ph.D. (Pennsylvania), Assistant Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

NELSON, THURLOW C(HRISTIAN), B.A., D.Sc. (Rutgers), Ph.D. (Wisconsin), Professor of Zoology, *Rutgers University;* Biologist, State Board of Shell Fisheries, *New Brunswick, N. J.*

NELSON, WARREN OTTO, A.B. (Augustana), Sc.M. (Iowa), Ph.D. (New York), Professor and Head of the Department of Anatomy; Chairman of the Division of Basic Sciences, Wayne University, College of Medicine, *1512 St. Antoine St., Detroit, Mich.*

NEWMAN, HORATIO HACKETT, B.A., Sc.D. (McMaster), Ph.D. (Chicago), Professor of Zoology, Emeritus, The University of Chicago, *173 Devon Drive, Clearwater, Fla.*

NICHOLAS, JOHN SPANGLER, S.B., S.M. (Gettysburg), Ph.D. (Yale), Sterling Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

NIGRELLI, ROSS F., B.S. (Pennsylvania State College), M.S., Ph.D. (New York), Pathologist, *New York Aquarium, New York Zoological Society, Bronx, New York, N. Y.*

NOLAND, LOWELL EVAN, B.A. (De Pauw), M.A., Ph.D. (Wisconsin), Professor of Zoology, *Biology Building, University of Wisconsin, Madison, Wis.*

NUTTYCOMBE, JOHN WILLIAM, B.S. (Va. Polytechnic Institute), Ph.D. (Virginia), Professor of Zoology, *LeConte Hall, University of Georgia, Athens, Ga.*

Obreshkove, Vasil, B.S., M.S. (Syracuse), Ph.D. (Harvard), Professor of Biology, Columbia University, *Bard College, Annandale-on-Hudson, N. Y.*

Okkelberg, Peter, A.B., A.M. (Minnesota), Ph.D. (Michigan), Professor of Zoology and Assistant Dean of the Horace H. Rackham School of Graduate Studies, University of Michigan, *1220 Fair Oaks, Ann Arbor, Mich.*

Old, Marcus Calvin, B.A., M.A. (Lehigh), Ph.D. (Michigan), Professor and Chairman of the Department of Biology, Hofstra College, *125 Duncan Rd., Hempstead, N. Y.*

Oliver, Clarence Paul, A.B., M.A., Ph.D. (Texas), Associate Professor of Zoology and Director Dight Institute, *Department of Zoology, University of Minnesota, Minneapolis, Minn.*

Olmsted, J. M. D., A.B., D.Sc., (Middlebury), B.A., M.A. (Oxford, England), M.A., Ph.D. (Harvard), Professor of Physiology, *University of California, Berkeley, Calif.*

Oppenheimer, Jane M., B.A. (Bryn Mawr), Ph.D. (Yale), Assistant Professor of Biology, *Bryn Mawr College, Bryn Mawr, Pa.*

O'Roke, Earl Cleveland, A.B., M.A. (Kansas), Ph.D. (California), Associate Professor of Forest Zoology, *4052 Natural Science Building, University of Michigan, Ann Arbor, Mich.*

Ortenburger, Arthur Irving, A.B., M.S., Ph.D. (Michigan), Professor of Zoology and Chairman of the Department, University of Oklahoma; Curator of Vertebrates, Museum of Zoology; Vertebrate Zoologist, Oklahoma Biological Survey, *University of Oklahoma, Norman, Okla.*

Osborn, Clinton Morris, A.B. (Bates), M.A., Ph.D. (Harvard), Assistant Professor of Histology and Embryology, *Department of Anatomy, Ohio State University, Columbus, Ohio.* (On leave for military service, '42. U. S. A.)

Osburn, Raymond C., Ph.D. (Columbia), Professor of Zoology, Emeritus, *Ohio State University, Columbus, Ohio.*

Pace, Donald Metcalf, A.B. (Susquehanna), M.A., Ph.D. (Duke), Assistant Professor in Physiology, *Department of Physiology and Pharmacology. The University of Nebraska, Lincoln, Nebr.*

Packard, Charles, B.S., M.S. (Syracuse), Ph.D. (Columbia), Sc.D. (Hon.) (Syracuse), Resident Director, Marine Biological Laboratory, *Woods Hole, Mass.*

Painter, Theophilus Schickel, A.B. (Roanoke), A.M., Ph.D., Sc.D. (Yale), Professor of Zoology, *University of Texas, Austin, Texas.*

Park, Orlando, B.S., Ph.D. (Chicago), Professor of Zoology, *Department of Zoology, Northwestern University, Evanston, Ill.*

Park, Thomas, S.B., Ph.D. (Chicago), Associate Professor of Zoology, Associate Dean, Division of Biological Sciences, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

†Parker, George Howard, S.B., D.Sc. (Harvard), Sc.D. (Colby), Professor of Zoology, Emeritus, Biological Laboratories, Harvard University, *16 Berkeley St., Cambridge, Mass.*

Parmenter, Charles Leroy, A.B., M.A. (Southern California), Ph.D. (Pennsylvania), Professor of Zoology, *Zoological Building, University of Pennsylvania, Philadelphia, Pa.*

PARPART, ARTHUR KEMBLE, B.A., M.A. (Amherst), Ph.D. (Pennsylvania), Associate Professor of Physiology, *Princeton University, Princeton, N. J.*

PARSHLEY, H(OWARD) M(ADISON), A.B., A.M., Sc.D. (Harvard), Professor of Zoology, *Smith College, Northampton, Mass.*

PATTEN, BRADLEY MERRILL, A.B. (Dartmouth), A.M., Ph.D. (Harvard), Professor of Anatomy and Director of Anatomical Laboratories, University of Michigan, Medical School, *2500 East Medical Bldg., Ann Arbor, Mich.*

PATTERSON, JOHN THOMAS, B.S., Sc.D. (Wooster), Ph.D. (Chicago), Professor of Zoology; Director of Zoological Research, University of Texas, *University Station, Austin, Texas.*

PATTERSON, THOMAS LEON, A.B. (Clark), A.M. (Kansas City), M.S., Ph.D. (Chicago), Professor of Physiology, Wayne University, College of Medicine, *1512 St. Antoine St., Detroit, Mich.*

PAYNE, FERNANDUS, A.B., A.M. (Indiana), Ph.D. (Columbia), Professor of Zoology, Dean of the Graduate School, Indiana University, *620 Ballentine Rd., Bloomington, Ind.*

PAYNE, NELLIE, M., B.S., M.S., (Kansas State), Ph.D. (Minnesota), Research Entomologist, *American Cyanamid Company, Boston Post Road, Stamford, Conn.*

PEARSE, ARTHUR SPERRY, B.S., A.M., LL.D. (Nebraska), Ph.D. (Harvard), Professor of Zoology, *Duke University, Durham, N. C.*

PEARSON, NATHAN EVERETT, A.B., A.M., Ph.D. (Indiana), Professor of Zoology, *Butler University, Indianapolis, Ind.*

PENNAK, ROBERT WILLIAM, B.S., M.S., Ph.D. (Wisconsin), Associate Professor of Biology, *Biology Department, University of Colorado, Boulder, Colo.*

PERKINS, HENRY F., A.B. (Vermont), Ph.D. (Johns Hopkins), Professor of Zoology and Director of Fleming Museum, University of Vermont, *205 S. Prospect St., Burlington, Vt.*

PETRUNKEVITCH, ALEXANDER, Ph.D. (Freiburg), M.A. Hon. (Yale), D.Sc. Hon. (Puerto Rico), Professor of Zoology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

PFEIFFER, CARROLL A., B.A. (Marietta), M.S., Ph.D. (Iowa), Research Assistant (Assistant Professor) in Anatomy, *Yale University, Department of Anatomy, 333 Cedar St., New Haven, Conn.*

PFEIFFER, ISABELLE WEED, B.A. (Wisconsin), M.S., Ph.D. (Iowa), Honorary Fellow in Zoology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

PHILIPS, FREDERICK STANLEY, B.A. (Columbia), Ph.D. (Rochester) Research Assistant, *Department of Pharmacology and Toxicology, Yale University Medical School, New Haven, Conn.*

PHILPOTT, CHARLES HUGHES, A.B., A.M., Ph.D. (Missouri), Principal, *Harris Teachers College, St. Louis, Mo.*

PIATT, JEAN, B.S. (Butler), M.A. (Haverford), Ph.D. (Yale), Instructor in Anatomy, *University of Pennsylvania, Philadelphia, Pa.*

PICKFORD, GRACE EVELYN, Nat. Sci. Tripos (Cambridge), Ph.D. (Yale), Research Assistant, Bingham Oceanographic Laboratory, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

PIKE, FRANK HENRY, A.B. (Indiana), Ph.D. (Chicago), Associate Professor of Physiology, Emeritus, Special Lecturer in Physiology, Columbia University, *437 West 59th St., New York 19, N. Y.*

PINCUS, GREGORY, B.S. (Cornell), M.S., D.Sc. (Harvard), Visiting Professor of Experimental Zoology, *Clark University, Worcester, Mass.*

PINNEY, MARY EDITH, A.B., A.M. (Kansas), Ph.D. (Bryn Mawr), Professor of Zoology, *Milwaukee-Downer College, Milwaukee, Wis.*

PLAGGE, JAMES C., S.B., Ph.D. (Chicago), Associate in Anatomy, *University of Illinois College of Medicine, 1853 W. Polk St., Chicago 12, Ill.*

PLOUGH, HAROLD HENRY, A.B. (Amherst), M.A., Ph.D. (Columbia), Professor of Biology, Amherst College, *85 Dana St., Amherst, Mass.* (On leave for military service, '42. Capt., U. S. A.)

POLLISTER, ARTHUR WAGG, A.B. (Bates), A.M., Ph.D. (Columbia), Associate Professor of Zoölogy, *Columbia University, New York, N. Y.*

POMERAT, CHARLES MARC, A.B. (Clark), A.M., Ph.D. (Harvard), Professor of Biology, University of Alabama, *Box 2047, University, Ala.*

PORTER, DALE ALBERT, A.B. (Kalamazoo College), M.S. (Kansas State College), Sc.D. (Johns Hopkins), Parasitologist, U. S. Regional Animal Disease Research Laboratory, *P.O. Drawer 952, Auburn, Ala.*

POTTER, GEORGE EDWIN, B.S. (Ottawa Univ., Kansas), M.S., Ph.D. (Iowa), Professor of Biology, Texas A. and M. College, *Box 1, F. E., College Station, Texas.*

POULSON, DONALD FREDERICK, B.S., Ph.D. (California Institute of Technology), Assistant Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

POWERS, EDWIN B., A.B. (Trinity), M.S. (Chicago), Ph.D. (Illinois), Professor of Zoology, Head of the Departments of Zoology and Entomology, *University of Tennessee, Knoxville, Tenn.*

PRATT, HENRY SHERRING, A.B. (Michigan), A.M., Ph.D. (Leipzig), Professor of Biology, Emeritus, *Haverford College, Haverford, Pa.*

PRICE, DOROTHY, B.S., Ph.D. (Chicago), Research Associate in Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

PRICE, JOHN WORTHINGTON, B.S., M.S., Ph.D. (Ohio State), Professor of Zoology, *Ohio State University, Columbus, Ohio.*

PROSSER, C(LIFFORD) LADD, A.B. (Rochester), Ph.D. (Johns Hopkins), Assistant Professor of Zoology, *University of Illinois, Urbana, Ill.*

PRYTHERCH, HERBERT FRANCIS, B.S. (Syracuse), Ph.D. (Pennsylvania), Director, *U. S. Fishery Biological Laboratory, Beaufort, N. C.*

PUCKETT, WILLIAM OLIN, A.B. (Davidson), A.M. (North Carolina), Ph.D. (Princeton), Assistant Professor of Comparative Anatomy and Vertebrate Embryology, *Department of Biology, Princeton University, Princeton, N. J.*

RAHN, HERMANN, A.B. (Cornell), Ph.D. (Rochester), Instructor in Physiology, *Department of Physiology, Rochester University, Rochester, N. Y.*

RAMSEY, ROBERT WEBERG, B.S., M.S., Ph.D. (New York), Associate in Physiology, *School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.*

RAND, HERBERT WILBUR, A.B. (Allegheny, Harvard), A.M., Ph.D. (Harvard), Associate Professor of Zoology, Emeritus, Harvard University, *Biological Laboratories, Cambridge, Mass.*

RANKIN, JOHN STEWART, JR., A.B., M.A. (Wesleyan), Ph.D. (Duke), Instructor in Zoology, Department of Biology, Amherst College, *R.F.D. no. 1, Amherst, Mass.*

RAWLES, MARY ELBERT, A.B. (Randolph-Macon Woman's College), S.M., Ph.D. (Chicago), Research Associate in Embryology, *Department of Biology, The Johns Hopkins University, Baltimore, Md.*

REDFIELD, ALFRED CLARENCE, B.S., Ph.D. (Harvard), Professor of Physiology, Harvard University, *Biological Laboratories, Harvard University, Cambridge, Mass.*

REESE, ALBERT MOORE, A.B., Ph.D. (Johns Hopkins), Professor of Zoölogy, *West Virginia University, Morgantown, W. Va.*

REHN, JAMES ABRAM GARFIELD, Curator of Entomology, Corresponding Secretary, *Academy of Natural Sciences, 1900 Race Street, Philadelphia, Pa.*

REINHARD, EDWARD G., A.B., A.M. (Woodstock), Ph.D. (Minnesota), Associate Professor of Biology and Head of the Department, *The Catholic University of America, Washington, D. C.*

REINKE, EDWIN EUSTACE, M.A. (Lehigh), Ph.D. (Princeton), Professor of Biology, *Vanderbilt University, Nashville, Tenn.*

REYNOLDS, BRUCE DODSON, B.S. (Virginia), Sc.D. (Johns Hopkins), Professor of Biology, *University of Virginia, University, Va.*

RHODES, ROBERT CLINTON, A.B. (Henderson Brown), A.B., A.M. (Vanderbilt), Ph.D. (California), Professor and Chairman of the Department of Biology, *Emory University, Emory, Ga.*

RICE, EDWARD LORANUS, A.B. (Wesleyan), Ph.D. (Munich), D.Sc. (Wesleyan), Professor of Zoology, Emeritus, *Ohio Wesleyan University, 265 N. Sandusky St., Delaware, Ohio.*

RICH, WILLIS H., B.S. (Lombard), A.B., A.M., Ph.D. (Stanford), Professor of Biology, *Stanford University, Calif.*

RICHARDS, ALBERT GLENN, JR., A.B. (Georgia), Ph.D. (Cornell), Instructor in Zoology, *Zoological Laboratory, University of Pennsylvania, Philadelphia, Pa.*

RICHARDS, AUTE, B.A. (Kansas), M.A. (Wisconsin), Ph.D. (Princeton), Sc.D. (Marietta), Professor of Zoology, Director, School of Applied Biology, University of Oklahoma, *434 Chautauqua, Norman, Okla.*

RICHARDS, MILDRED HOGE, A.B. (Goucher), A.M., Ph.D. (Columbia), *434 Chautauqua, Norman, Okla.*

RICHARDS, OSCAR W., A.B., A.M. (Oregon), Ph.D. (Yale), Research Biologist, Spencer Lens Co., *19 Doat St., Buffalo 11, N. Y.*

RICKER, WILLIAM EDWIN, B.A., M.A., Ph.D. (Toronto), Associate Professor of Zoology, *Department of Zoology, Indiana University, Bloomington, Ind.*

RIDDLE, OSCAR, A.B. (Indiana), Ph.D. (Chicago), LL.D. (Indiana), Research Staff, Carnegie Institution, Station for Experimental Evolution, *Cold Spring Harbor, Long Island, N. Y.*

RILEY, GARDNER M., B.A. (St. Stephen's College), M.S., Ph.D. (Iowa), Instructor in Obstetrics and Gynecology, University of Michigan Medical School, Ann Arbor, Mich.

RILEY, WILLIAM ALBERT, B.S. (DePauw), Ph.D. (Cornell), Chief of Division of Entomology and Economic Zoology, *University of Minnesota, University Farm, St. Paul, Minn.*

RINGOEN, ADOLPH R., B.A. (Iowa), M.A., Ph.D. (Minnesota), Professor of Zoology, *University of Minnesota, Minneapolis, Minn.*

RISLEY, PAUL LEMUEL, A.B. (Albion), M.S., Ph.D. (Michigan), Associate Professor, *Department of Zoology, State University of Iowa, Iowa City, Iowa.*

RITTER, WILLIAM E., B.S. (California), Ph.D. (Harvard), LL.D. (California), Museum of Vertebrate Zoology, *University of California, Berkeley, Calif.*

ROBERTS, ELMER, B.S., Ph.D. (Illinois), Professor of Animal Genetics, *University of Illinois, College of Agriculture, Urbana, Ill.*

ROBERTS, HOWARD RADCLYFFE, B.S. (Princeton), Ph.D. (Pennsylvania), Research Associate in Entomology, *Academy of Natural Sciences, 19th and Race Streets, Philadelphia, Pa.*

ROGERS, CHARLES GARDNER, A.B., A.M. (Syracuse), Ph.D. (California), Sc.D. (Syracuse), Professor of Comparative Physiology, Oberlin College, *378 Reamer Place, Oberlin, Ohio.*

ROGICK, MARY DORA, A.B., A.M. (Nebraska), Ph.D. (Ohio State), Professor of Biology, College of New Rochelle, *25 Prospect St., Apt. 1-K, New Rochelle, N. Y.*

ROMANOFF, ALEXIS LAWRENCE, B.S., M.S., Ph.D. (Cornell), Associate Professor (Experimental Avian Embryology), *Department of Poultry Husbandry, Cornell University, Ithaca, N. Y.*

ROMER, ALFRED SHERWOOD, A.B. (Amherst), Ph.D. (Columbia), Professor of Zoology, Biological Laboratories, *Harvard University, Cambridge, Mass.*

ROOT, RAYMOND WILLARD, B.A. (Milton), A.M., Ph.D. (Duke), Assistant Professor of Biology, *College of the City of New York, 139th St. and Convent Ave., New York, N. Y.*

ROSENBERG, LAUREN EMERY, B.S. (Knox), M.A., Ph.D. (California), Assistant Professor of Zoology, and Assistant Zoologist in the Experiment Station, *Zoology Division, University of California, Davis, Calif.* (On leave for military service, '41. Lt. (jg) H-V (S), U. S. N. R.)

ROSENE, HILDA FLORENCE, B.S., M.S., (Washington), Ph.D. (Texas), Associate Professor of Physiology, *University of Texas, Austin, Texas.*

RUDNICK, DOROTHEA, Ph.B., Ph.D. (Chicago), Assistant Professor of Biology, *Albertus Magnus College, 700 Prospect St., New Haven, Conn.*

RUGH, ROBERTS, A.B., M.A. (Oberlin), Ph.D. (Columbia), Associate Professor of Zoology, *Washington Square College, New York University, New York, N. Y.*

RULON, OLIN, B.A. (Park), M.S. (Oklahoma), Ph.D. (Chicago), Assistant Professor of Biology, *Wayne University, Detroit, Mich.*

RUTH, ELBERT BRESEE, A.B., (Indiana), A.M., Ph.D. (Wisconsin), Assistant Professor of Anatomy, *Department of Anatomy, College of Medicine, Eden Ave., University of Cincinnati, Cincinnati, Ohio.*

RUTHVEN, ALEXANDER G., B.S. (Morningside), Ph.D. (Michigan), Sc.D. (Kalamazoo, Michigan College of Mining and Technology), LL.D. (Albion, Northwestern, Morningside, Denison, Tulane, California), President, *University of Michigan, Ann Arbor, Mich.*

SAMPSON, MYRA MELISSA, Ph.B. (Brown), A.M., Ph.D. (Michigan), Professor of Zoology, *Department of Zoology, Smith College, Northampton, Mass.*

SANDOW, ALEXANDER, B.S. (Massachusetts State), M.A. (Columbia), Ph.D. (New York), Assistant Professor of Biology, *Washington Square College of Arts and Science, New York University, New York, N. Y.*

SANDSTROM, CARL JOHAN, B.S., Ph.D. (Chicago), Associate Professor, *Department of Biology, New York University, University Heights, New York, N. Y.*

SAWIN, PAUL BALDWIN, B.S. (Cornell), M.S. (Kansas State), Sc.D. (Harvard), Assistant Professor of Biology, *Brown University, Providence, R. I.*

SAYLES, LEONARD P., A.B., A.M., Ph.D. (Brown), Assistant Professor of Biology, *College of the City of New York, 139th and Convent Ave., New York, N. Y.*

SCHAEFFER, ASA ARTHUR, A.B. (Franklin and Marshall), Ph.D. (Johns Hopkins), Professor of Biology, *Temple University, Philadelphia, Pa.*

SCHECHTER, VICTOR, B.S. (College of the City of New York), M.A., Ph.D. (Columbia), Assistant Professor of Biology, *College of the City of New York, New York, N. Y.*

SCHIEDT, RICHARD C. F., Ph.D. (Pennsylvania), Sc.D. (Hon.) (Franklin and Marshall), *1043 Wheatland Ave., Lancaster, Pa.*

SCHMIDT, IDA GENTHER, B.A. (Mt. Holyoke), M.A. (Wisconsin), Ph.D. (Washington), Assistant Professor of Anatomy, *College of Medicine, Eden Ave., Cincinnati, Ohio.*

SCHMIDT, KARL PATTERSON, B.A. (Cornell), Chief Curator of Zoology, *Chicago Natural History Museum, Chicago, Ill.*

SCHMITT, FRANCIS OTTO, A.B., Ph.D. (Washington University), Professor of Biology, Head of the Department of Biology and Biological Engineering, *Massachusetts Institute of Technology, Cambridge, Mass.*

SCHMITT, WALDO LA SALLE, B.A., Ph.D. (George Washington), M.A. (California), Head Curator Department of Biology, *U. S. National Museum, Washington, D. C.*

SCHNEIDER, BYRON AUBREY, A.B. (Western Maryland College), Sc.D. (Johns Hopkins), National Research Council Representative, Office of the Air Surgeon, *Hq. Army Air Forces, Washington, D. C.*

SCHOLANDER, PER FREDRIK, Ph.D. (Oslo), Research Associate in Biology, *Martin Biological Laboratories, Swarthmore, Pa.*

SCHOOLEY, JAMES PLUMMER, A.B., Ph.D. (Indiana), Director, Department of Endocrinology, *Difco Laboratories, Inc., Detroit, Mich.*

SCHOTTÉ, OSCAR EMIL, Licencié ès Sciences physiques et naturelles, D.Sc. (Geneva), Associate Professor of Biology, *Amherst College, Amherst, Mass.*

SCHRADER, FRANZ, B.S., Ph.D. (Columbia), Professor of Zoology, *Columbia University, New York, N. Y.*

SCHWEIZER, MALVINA, B.S., M.S., Ph.D. (New York), Instructor in Biology, Washington Square College, New York University, *50 West 67th St., New York, N. Y.*

SCHWITALLA, ALPHONSE MARY, A.B., A.M. (St. Louis), Ph.D. (Johns Hopkins), LL.D. (Tulane), D.Sc. (Lawrence College), Professor of Biology and Dean, St. Louis University School of Medicine, *1402 S. Grand Blvd., St. Louis, Mo.*

SCOTT, GEORGE G., A.B., A.M. (Williams), Ph.D. (Columbia), Professor of Biology, Emeritus, College of the City of New York, *460 Henkel Circle, Winter Park, Fla.*

SCOTT, GORDON HATLER, A.B. (Southwestern College, Kansas), M.A., Ph.D. (Minnesota), Professor of Anatomy and Chairman of the Department, *University of Southern California School of Medicine, Los Angeles 7, Calif.*

SCOTT, JAMES ALLEN, A.B., A.M. (Wesleyan), Sc.D. (Johns Hopkins), Public Health Biologist and Associate Director, Malaria and Hookworm Service, *Georgia State Health Department, Atlanta, Ga.*

SCOTT, JOHN W., A.B., A.M. (Missouri), Ph.D. (Chicago), Professor of Zoölogy, Research Parasitologist, (Limited service), University of Wyoming, *1409 Garfield St., Laramie, Wyo.*

SEEVERS, CHARLES HAMILTON, A.B. (Washburn College), Ph.D. (Chicago), Associate Professor of Zoology, *Central Y. M. C. A. College, 19 South LaSalle St., Chicago, Ill.*

SELF, JOHN TEAGUE, B.A., M.A. (Baylor), Ph.D. (Oklahoma), Associate Professor of Zoology, *Department of Zoology, University of Oklahoma, Norman, Okla.*

SHAPIRO, HERBERT, B.S., M.A. (Columbia), Ph.D. (Princeton), Instructor in Physiology, *Department of Physiology, Hahnemann Medical College, Philadelphia, Pa.*

SHAVER, JESSE MILTON, B.S.A. (Tennessee), M.S. (Vanderbilt), Ph.D. (Chicago), Professor of Biology, *George Peabody College for Teachers. Nashville, Tenn.*

SHELFORD, VICTOR ERNEST, B.S., Ph.D. (Chicago), Professor of Zoology, University of Illinois, *Vivarium Building, Wright and Healey Sts., Champaign, Ill.*

SHETTLES, LANDRUM BREWER, A.B. (Mississippi College), M.S. (New Mexico), Ph.D., M.D. (Johns Hopkins), Assistant in Obstetrics, *The Johns Hopkins University and Hospital, Department of Obstetrics, Baltimore 5, Md.*

SHULL, A(ARON) FRANKLIN, A.B. (Michigan), Ph.D. (Columbia), Professor of Zoology, University of Michigan, *431 Highland Road, Ann Arbor, Mich.*

SHUMWAY, WALDO, A.B. (Amherst), A.M., Ph.D. (Columbia), Professor of Zoology, *317 N. H. Bldg., University of Illinois, Urbana, Ill.*

SICHEL, FERDINAND J. M., B.Sc. (McGill), Sc.M., Ph.D. (New York), Associate Professor of Physiology, *College of Medicine, University of Vermont, Burlington, Vt.*

SIGERFOOS, CHARLES P., B.S. (Ohio State), Ph.D. (Johns Hopkins), Professor of Zoology, Emeritus, *Arcanum, Ohio.*

SIZER, IRWIN W(HITING), A.B. (Brown), Ph.D. (Rutgers), Associate Professor of Physiology, *Massachusetts Institute of Technology, Cambridge, Mass.*

SKOGSBERG, KARL JONAS TAGE, M.A., Ph.D. (Upsala, Sweden), Professor of Marine Biology and Oceanography, Stanford University, California, *Hopkins Marine Station, Pacific Grove, Calif.*

SLIFER, ELEANOR HEIST, B.S. (Temple), M.S., Ph.D. (Pennsylvania), Assistant Professor of Zoology, *Department of Zoology, University of Iowa, Iowa City, Iowa.*

SMALLWOOD, WILLIAM MARTIN, Ph.D., D.Sc. (Harvard), Professor of Comparative Anatomy, Emeritus, Syracuse University, *525 Euclid Ave., Syracuse, N. Y.*

SMELSER, GEORGE KEISER, A.B. (Earlham), Ph.D. (Chicago), Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 W. 168th St., New York, N. Y.*

SMITH, BERTRAM GARNER, A.B. (Michigan), Ph.D. (Columbia), Professor of Anatomy, New York University College of Medicine. (79 Miller Ave., Tarrytown, N. Y.), *Route 2, Box 50, Albuquerque, N. Mex.*

SMITH, CHRISTIANNA, A.B., (Mt. Holyoke), A.M., Ph.D. (Cornell), Professor of Zoology, *Mt. Holyoke College, South Hadley, Mass.*

SMITH, DIETRICH CONRAD, A.B., A.M. (Minnesota), Ph.D. (Harvard), Associate Professor of Physiology, *University of Maryland, School of Medicine, Baltimore, Md.*

SNELL, GEORGE D., B.S. (Dartmouth), M.S., Sc.D. (Harvard), Research Associate, *Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.*

SNYDER, LAURENCE HASBROUCK, B.S. (Rutgers), M.S., Sc.D. (Harvard), Professor of Zoology and Chairman of the Department, *Department of Zoology, Ohio State University, Columbus, Ohio.*

SONNEBORN, TRACY MORTON, A.B., Ph.D. (Johns Hopkins), Professor of Zoology, *Indiana University, Bloomington, Ind.*

SPEICHER, BENJAMIN ROBERT, A.B. (Denison), M.S., Ph.D. (Pittsburgh), Associate Professor of Zoology, *Department of Zoology, University of Maine, Orono, Me.*

SPEIDEL, CARL CASKEY, Ph.B. (Lafayette), Ph.D. (Princeton), Sc.D. (Lafayette), Professor of Anatomy, *University of Virginia Medical School, University, Va.*

SPENCER, WARREN POPPINO, B.A. (Wooster), M.S., Ph.D. (Ohio State), Professor of Biology, *Wooster College, Wooster, Ohio.*

SPRATT, NELSON TRACY, JR., A.B. (Emory), Ph.D. (Rochester), Research Assistant in Embryology and Instructor in Biology, *The Johns Hopkins University, Baltimore, Md.*

STABLER, ROBERT MILLER, A.B. (Swarthmore), Sc.D. (Johns Hopkins), Assistant Professor of Zoology, *Department of Zoology, University of Pennsylvania, Philadelphia, Pa.*

STANLEY, WILLARD FRANCIS, A.B. (North Central), A.M., Ph.D. (Illinois), Head of the Science Department, *State Teachers College, Fredonia, N. Y.*

STEGGERDA, FREDERIC RUSSELL, A.B. (Hope), M.A., Ph.D. (Minnesota), Associate Professor of Physiology, *416 Natural History Building, University of Illinois, Urbana, Ill.*

STEGGERDA, MORRIS, A.B. (Hope), A.M., Ph.D. (Illinois), Investigator, Department of Genetics, Carnegie Institution of Washington, *Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

STEINBACH, HENRY BURR, A.B. (Michigan), M.A. (Brown), Ph.D. (Pennsylvania), Assistant Professor of Zoology, *Department of Zoology, Columbia University, New York, N. Y.*

STEINBERG, ARTHUR G., B.Sci. (College of the City of New York), M.A., Ph.D. (Columbia), Lecturer, *Department of Genetics, McGill University, Montreal, Quebec, Canada.*

STEINER, GOTTHOLD, Ph.D. (Berne), Bureau of Plant Industry, U. S. Department *of Agriculture, Washington, D. C.*

STERN, CURT, Ph.D. (Berlin), Professor of Experimental Zoology, Chairman, Division of Biological Sciences, *University of Rochester, Rochester, N. Y.*

STEWART, COLIN CAMPBELL, A.B. (Toronto), Ph.D. (Clark), Brown Professor of Physiology, Dartmouth College, *3 Dana Road, Hanover, N. H.*

STIER, THEODORE JAMES BLANCHARD, B.S. (Rutgers), M.A., Ph.D. (Harvard), Associate Professor of Physiology, *Indiana University School of Medicine, Bloomington, Ind.*

STILES, KARL A., A.B. (Battle Creek), M.S., Ph.D. (Michigan), Bert H. Bailey Professor of Biology and Chairman of the Division of Natural Sciences, *Coe College, Cedar Rapids 20, Iowa.*

STILWELL, E. FRANCES, A.B., A.M. (Smith), Ph.D. (Bryn Mawr), Associate Professor of Anatomy, *Department of Anatomy, Woman's Medical College of Pennsylvania, Philadelphia, Pa.*

STOLL, NORMAN RUDOLPH, B.S. (Mt. Union), M.S. (Michigan), Sc.D. (Johns Hopkins), Associate Member *Rockefeller Institute for Medical Research, Department of Animal Pathology, Princeton, N. J.*

STONE, R. G., Ph.D. (Missouri), Professor of Biology, *University of Kansas City, Kansas City, Mo.*

STRANDSKOV, HERLUF HALDAN, A.B. (Iowa State Teachers), M.S. (Illinois), Ph.D. (Chicago), Assistant Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

STREETER, GEORGE LINIUS, A.B., Sc.D. (Union), A.M., M.D. (Columbia), Sc.D. (Dublin), LL.D. (Michigan), Research Associate, Carnegie Institution of Washington, *The Johns Hopkins Medical School, 710 North Washington St., Baltimore 5, Md.*

STRONG, OLIVER S., A.B., A.M. (Princeton), Ph.D. (Columbia), Professor of Neurology and Neuro-Histology, Emeritus, College of Physicians and Surgeons, *630 W. 168th St., New York, N. Y.*

STRONG, REUBEN MYRON, A.B. (Oberlin), M.A., Ph.D. (Harvard), Professor of Anatomy, Loyola University School of Medicine, *706 South Wolcott St., Chicago 12, Ill.*

STUNKARD, HORACE W., B.S. (Coe), A.M., Ph.D. (Illinois), Professor of Biology, *New York University, University Heights, New York, N. Y.*

STURTEVANT, ALFRED HENRY, A.B., Ph.D. (Columbia), Professor of Genetics, *California Institute of Technology, Pasadena 4, Calif.*

SUMMERS, F(RANCIS) M(ARION), A.B. (California), M.A., Ph.D. (Columbia), Department of Biology, *College of the City of New York, New York, N. Y.*

SUMNER, FRANCIS BERTODY, B.S. (Minnesota), Ph.D. (Columbia), Professor of Biology, Scripps Institution of Oceanography, *University of California, La Jolla, Calif.*

SWEETMAN, HARVEY LEROY, B.S. (Colorado Agricultural), M.S. (Iowa State), Ph.D. (Massachusetts State), Assistant Professor of Entomology, *Massachusetts State College, Amherst, Mass.*

SWINGLE, WILBUR WILLIS, A.B., A.M. (Kansas), Ph.D. (Princeton), Professor of Biology, *Princeton University, Princeton, N. J.*

TALIAFERRO, WILLIAM HAY, B.S. (Virginia), Ph.D. (Johns Hopkins), Eliakim H. Moore Distinguished Service Professor of Parasitology, Chairman of the Department of Bacteriology and Parasitology; Dean of the Division of Biological Sciences, *The University of Chicago, 950 E. 59th St., Chicago, 37, Ill.*

TAYLOR, AUBREY BRYANT, Ph.B. (Brown), M.S., Ph.D. (Iowa), Instructor in Physiology, University of Illinois, *402 Natural History Building, Urbana, Ill.*

TAYLOR, CHARLES VINCENT, Ph.D. (California), Professor of Biology, *Stanford University, Calif.*

TAYLOR, GEORGE WELLFORD, B.A. (Richmond), M.A., Ph.D. (Princeton), Assistant Professor of Zoology, *Washington University, St. Louis, Mo.*

THOMAS, LYELL JAY, B.S. (Fargo), M.S., Ph.D. (Illinois), Associate Professor of Zoology, University of Illinois, *103 Vivarium Bldg., Champaign, Ill.*

TORREY, THEODORE WILLETT, A.B. (Denver), M.A., Ph.D. (Harvard), Associate Professor of Zoology, *Department of Zoology, Indiana University, Bloomington, Ind.*

TRAGER, WILLIAM, B.S., (Rutgers), M.A., Ph.D. (Harvard), Associate, Rockefeller Institute, *Department of Animal and Plant Pathology, Rockefeller Institute, Princeton, N. J.*

TREADWELL, AARON L., B.S., M.S., Sc.D. (Wesleyan), Ph.D. (Chicago), Professor of Zoology, Emeritus, *Vassar College, Poughkeepsie, N. Y.*

TRESSLER, WILLIS LATTANNER, B.A., M.A., Ph.D. (Wisconsin), Assistant Professor of Zoology, Planktologist, Chesapeake Biological Laboratory, *Department of Zoology, University of Maryland, College Park, Md.*

TURNER, CLARENCE DONNELL, A.B. (Westminister), A.M., Ph.D. (Missouri), Assistant Professor of Zoology, *Department of Zoology, Northwestern University, Evanston, Ill.*

TURNER, CLARENCE LESTER, A.B., A.M. (Ohio Wesleyan), Ph.D. (Wisconsin), Professor of Zoology, *Northwestern University, Evanston, Ill.*

TWITTY, VICTOR CHANDLER, B.S. (Butler), Ph.D. (Yale), Professor of Biology, *School of Biology, Stanford University, Palo Alto, Calif.*

TYLER, ALBERT, A.B., A.M. (Columbia), Ph.D. (California Institute of Technology), Assistant Professor of Embryology, *Department of Zoology, California Institute of Technology, Pasadena 4, Calif.*

UNGER, WILLIAM BYERS, B.A., M.S., Ph.D. (Yale), M.A. (Hon.) (Dartmouth), Professor of Zoology, *Dartmouth College, Hanover, N. H.*

VAN CLEAVE, CHARLES DURWARD, A.B. (Colorado), Ph.D. (Chicago), *Department of Anatomy, Cornell University Medical College, 1300 York Ave., New York, N. Y.*

VAN CLEAVE, HARLEY JONES, B.S. (Knox), M.S., Ph.D. (Illinois), Professor of Zoology, *318 Natural History Building, University of Illinois, Urbana, Ill.*

VAN DER SCHALIE, HENRY, A.B. (Calvin), M.S., Ph.D. (Michigan), Assistant Curator of Mollusks and Instructor in Zoology, University of Michigan, *Museum of Zoology, Ann Arbor, Mich.*

VAN DEVENTER, WILLIAM CARL, A.B. (Central), A.M., Ph.D. (Illinois), Teacher of Zoology, *Division of Science, Stephens College, Columbia, Mo.*

VILLEE, CLAUDE ALVIN, JR., B.S. (Franklin and Marshall), Ph.D. (California), Assistant Professor of Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.*

VISSCHER, J. PAUL, A.B. (Hope), A.M., Ph.D. (Johns Hopkins), Professor of Biology, *Western Reserve University, Cleveland, Ohio.*

WAGNER, GEORGE, B.A. (Kansas), M.A. (Michigan), Professor of Zoology, *University of Wisconsin, Biology Building, Madison, Wis.*

WAITE, FREDERICK CLAYTON, Litt.B. (Adelbert), A.M., H.H.D. (Western Reserve), A.M., Ph.D. (Harvard), Professor of Histology and Embryology, Emeritus, Western Reserve University, *144 Locust St., Dover, N. H.*

WALLS, GORDON LYNN, B.S. (Tufts), A.M. (Harvard), Sc.D. (Michigan), Scientific Bureau, *Bausch and Lomb Optical Company, Rochester, N. Y.*

WALTER, HERBERT EUGENE, A.B. (Bates), A.M. (Brown), Ph.D. (Harvard), Sc.D. (Middlebury, Bates), Professor of Biology, Emeritus, *Brown University, Providence, R. I.*

WALTON, ARTHUR CALVIN, B.A., M.A. (Northwestern), Ph.D. (Illinois), Wallace C. Abbott Professor of Biology, Chairman of the Department, *Knox College, Galesburg, Ill.*

WALZL, EDWARD McCOLGAN, M.A., Ph.D., M.D. (Johns Hopkins), Associate in Oto-Laryngology, *The Johns Hopkins University, School of Medicine, Baltimore, Md.*

WANTLAND, WAYNE W., B.S., A.M., Ph.D. (Northwestern), Co-Director of Biological Science, *Stephens College, Columbia, Mo.*

WARD, HENRY B(ALDWIN), A.B. (Williams), A.M., Ph.D. (Harvard), Sc.D. (Williams), LL.D. (Nebraska), Professor of Zoology, Emeritus, *University of Illinois, Urbana, Ill.*

WARREN, ARTHUR EMERSON, B.A. (Acadia), Ph.D. (Harvard), Associate Professor of Zoology, *McMaster University, Hamilton, Ontario, Canada.*

WARREN, DON C., A.B., A.M. (Indiana), Ph.D. (Columbia), Poultry Geneticist, *Kansas State College, Manhattan, Kan.*

WARWICK, BRUCE LESTER, D.V.M. (Iowa State College), M.S., Ph.D. (Wisconsin), Animal Geneticist, *Division of Range Animal Husbandry, Texas Experiment Station, College Station, Texas.*

WATANABE, YISAMU, Rigakushi, Graduate of the Faculty of Natural Science, Imperial Universities of Japan, Rigakuhakushi (Sendai), Independent Investigator (Private Laboratory), *10, Nakajima Park, Sapporo, Japan.*

WATERMAN, ALLYN JAY, A.B. (Oberlin), A.M. (Western Reserve), Ph.D. (Harvard), Associate Professor of Biology, *Williams College, Williamstown, Mass.*

WEED, LEWIS HILL, A.B. (Yale), M.D. (Johns Hopkins), Sc.D. (Rochester, Pennsylvania), LL.D. (Duke), LL.D. (Tufts), Director of Medical School and Professor of Anatomy, *The Johns Hopkins Medical School, Baltimore, Md.*

WEESE, ASA ORRIN, A.B. (Minnesota), A.M., Ph.D. (Illinois), Professor of Zoology, *University of Oklahoma, Norman, Okla.*

WEICHERT, CHARLES K., B.S. (Rutgers), M.S., Ph.D. (Wisconsin), Professor of Zoology, *University of Cincinnati, Cincinnati, Ohio.*

WEILL, ROBERT F., Sc.D. (Paris), Chef de Travaux à la Faculté des Sciences de Paris, *105 Boulevard Raspail, Paris VI, France.*

WEIMER, BERNAL R(OBINSON), A.B., A.M. (West Virginia), Ph.D. (Chicago), Professor of Biology and Dean of the Faculty, *Bethany College, Bethany, W. Va.*

WEINSTEIN, ALEXANDER, B.S., M.A., Ph.D. (Columbia), *Zoological Laboratory, Columbia University, New York, N. Y.*

WEISS, PAUL ALFRED, Ph.D. (Vienna), Professor of Zoology, Hull Zoological Laboratory, *The University of Chicago, Chicago 37, Ill.*

WEISSENBERG, JULIUS RICHARD, M.D. (Berlin), Professor of Histology and Embryology, *Middlesex University, School of Medicine, Waltham, Mass.*

WELCH, D'ALTE ALDRIDGE, M.A., Ph.D. (Johns Hopkins), Instructor of Biology, *John Carroll University, Cleveland, Ohio.*

WELCH, PAUL SMITH, A.B. (James Millikin), A.M., Ph.D. (Illinois), Professor of Zoology, *University of Michigan, Ann Arbor, Mich.*

WELLS, LEMEN JONATHAN, Ed.B. (So. Illinois State Teachers College), A.M. (Northwestern), Ph.D. (Chicago), Associate Professor of Anatomy, *Department of Anatomy, University of Minnesota, Minneapolis, Minn.*

WELSH, JOHN H., A.B. (Berea), M.A., Ph.D. (Harvard), Associate Professor of Zoology and Tutor in Biology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

WENNER, WILLIAM FRANKLIN, B.A. (Lebanon Valley), Ph.D. (Yale), M.D. (Washington University, St. Louis), Medical Division, *The Upjohn Co., Kalamazoo, Mich.*

WENRICH, DAVID HENRY, B.A., M.A. (Kansas), Ph.D. (Harvard), Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

WHARTON, GEORGE WILLARD, JR., B.S., Ph.D. (Duke), Instructor in Zoology, *Zoology Department, Duke University, Durham, N. C.*

WHEDON, ARTHUR D., B.A. (Iowa), Ph.D. (Pennsylvania), Professor of Zoology, *North Dakota Agricultural College, Fargo, N. D.*

WHITAKER, DOUGLAS (MERRITT), A.B., Ph.D. (Stanford), Professor of Biology, *Stanford University, Stanford University, Calif.*

WHITING, ANNA RACHEL (Mrs.), A.B. (Smith), Ph.D. (Iowa), Associate Professor of Zoology, *Swarthmore College, Swarthmore, Pa.*

WHITING, PHINEAS WESCOTT, A.B., M.S. (Harvard), Ph.D. (Pennsylvania), Associate Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

WHITNEY, DAVID DAY, B.A. (Wesleyan), M.A., Ph.D. (Columbia), Chairman, Department of Zoology, *University of Nebraska, Lincoln, Nebr.*

WICHTERMAN, RALPH, B.S. (Temple), M.A., Ph.D. (Pennsylvania), Assistant Professor of Biology, *Biology Department, Temple University, Philadelphia, Pa.*

WIEMAN, HARRY LEWIS, A.B., A.M. (Cincinnati), Ph.D. (Chicago), Professor of Zoology, *University of Cincinnati, Cincinnati, Ohio.*

WILLARD, W. A., A.B. (Grinnell), A.M. (Tufts, Harvard), Ph.D. (Harvard), Professor of Anatomy, *University Medical College of Nebraska, 42nd St. and Dewey Ave., Omaha, Nebr.*

WILLEY, CHARLES HERBERT, A.B., Sc.M., Ph.D. (New York), Assistant Professor of Biology, *New York University, University Heights, N. Y.*

WILLIAMS, CARROLL MILTON, B.S. (Richmond), A.M., Ph.D. (Harvard), Junior Prize Fellow in Biology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

WILLIAMS, STEPHEN RIGGS, A.B., A.M. (Oberlin), A.M., Ph.D. (Harvard), Professor of Zoology, Emeritus, Miami University, *300 East Church St., Oxford, Ohio.*

WILLIER, BENJAMIN H(ARRISON), B.S., Sc.D. (Wooster), Ph.D. (Chicago), Henry Walters Professor of Zoology, Chairman of the Department of Biology, *Department of Biology, The Johns Hopkins University, Baltimore 18, Md.*

WILSON, FRANCIS HENRY, B.S., M.S., Ph.D. (Cornell), Associate Professor of Parasitology, Department of Tropical Medicine, and Associate Professor of Zoology, *Department of Zoology, Tulane University, New Orleans, La.*

WILSON, IRA TEMPLIN, A.B., A.M., Ph.D. (Indiana), Professor of Biology, *Heidelberg College, Tiffin, Ohio.*

WILSON, J(AMES) WALTER, Ph.B., Ph.D. (Brown), Associate Professor of Biology, Brown University, *282 Doyle Ave., Providence, R. I.*

WISLOCKI, GEORGE BERNAYS, A.B. (Washington), M.D. (Johns Hopkins), James Stillman Professor of Comparative Anatomy, *Harvard Medical School, 25 Shattuck St., Boston, Mass.*

WITSCHI, EMIL, Ph.D. (Munich), Professor of Zoology, (Experimental Embryology), *State University of Iowa, Iowa City, Iowa.*

WODSEDALEK, JERRY EDWARD, Ph.B., M.Ph., Ph.D. (Wisconsin), Professor of Zoology, *University of Minnesota, Minneapolis, Minn.*

WOLF, ERNST, Ph.D. (Heidelberg), Research Associate, *Biological Laboratories, Harvard University, Divinity Ave., Cambridge, Mass.*

WOLFE, HAROLD R(ECLUS), B.S. (Miami, Fla.), M.S. (Rutgers), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Biology Building, University of Wisconsin, Madison, Wis.*

WOODSIDE, GILBERT LLEWELLYN, A.B. (DePauw), A.M., Ph.D. (Harvard), Assistant Professor of Biology, *Department of Entomology and Zoology, Massachusetts State College, Amherst, Mass.*

WOODRUFF, LORANDE LOSS, A.B., Ph.D. (Columbia), M.A. Hon. (Yale), Professor of Protozoology and Director of the Osborn Zoological Laboratory, *Yale University, New Haven, Conn.*

WOODWARD, ALVALYN E., Ph.B., M.S. (Rochester), Ph.D. (Michigan), Assistant Professor of Zoology, *University of Michigan, Ann Arbor, Mich.*

WORLEY, LEONARD GEORGE, A.B., M.A. (Nebraska), Ph.D. (Harvard), Assistant Professor, *Department of Biology, Brooklyn College, N. Y.*

WRIGHT, ALBERT HAZEN, A.B., A.M., Ph.D. (Cornell), Professor of Zoology, Cornell University, *113 E. Upland Road, Ithaca, N. Y.*

WRIGHT, SEWALL, B.S. (Lombard), M.S. (Illinois), Sc.D. (Harvard), Ernest D. Burton Distinguished Service Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago 37, Ill.*

WYMAN, JEFFRIES, JR., A.B. (Harvard), Ph.D. (University College, London), Associate Professor of Zoology, Harvard University, *Biological Laboratories, Divinity Ave., Cambridge, Mass.*

YEAGER, J(AMES) FRANKLIN, Ph.B. (Yale), M.A., (Columbia), Ph.D. (New York), Senior Entomologist, *Bureau of Entomology and Plant Quarantine, Bldg. A., Beltsville, Md.*

YOCOM, HARRY BARCLAY, A.B. (Oberlin), M.A., Ph.D. (California), Professor of Zoology, *University of Oregon, Eugene, Ore.*

YOUNG, BENJAMIN P., B.S. (Kansas), Ph.D. (Cornell), Associate Professor of Zoology, Cornell University, *117 Parkway, Ithaca, N. Y.*

YOUNG, R. T., B.S. (Pennsylvania), Ph.D. (Nebraska), *Scripps Institution of Oceanography, La Jolla, Calif.*

YOUNG, WILLIAM CALDWELL, A.B., A.M. (Amherst), Ph.D. (Chicago), Associate Professor of Primate Biology, Yale University School of Medicine, *Yerkes Laboratory of Primate Biology, Orange Park, Fla.*

ZAHL, PAUL ARTHUR, A.B. (North Central), A.M., Ph.D. (Harvard), Research Associate, *The Haskins Laboratory, Schenectady, N. Y.*

ZIRKLE, RAYMOND E., A.B., Ph.D. (Missouri), Professor of Botany, *Indiana University, Bloomington, Ind.* (On leave for military service, '42.)

ASSOCIATE MEMBERS

ALDERMAN, ALTON LOVELL, A.B., Ph.D. (California), Assistant Professor of Zoology, *University of Oregon, Eugene, Ore.*

ALEXANDER, LLOYD EPHRAIM, A.M. (Michigan), Ph.D. (Rochester), Assistant Professor of Biology, *Fisk University, Nashville, Tenn.*

ALLEN, THOMAS HUNTER, B.A., Ph.D. (Iowa), Research Associate in Zoology, *Department of Zoology, State University of Iowa, Iowa City, Iowa.*

ALTLAND, PAUL DANIEL, B.S. (Gettysburg), M.A., Ph.D. (Duke), Assistant Professor of Biology, *Department of Biology, Gettysburg College, Gettysburg, Pa.*

ANDREW, WARREN, A.B. (Carleton), M.S. (Brown), Ph.D. (Yale, Illinois), M.D. (Baylor), Associate Professor of Histology and Embryology, *Southwestern Medical Foundation School of Medicine, Dallas, Texas.*

ASHKENAZ, ELEANOR WEINER, B.S., Ph.D. (Pennsylvania), Research Associate, *Zoology Department, University of Pennsylvania, Philadelphia, Pa.*

BAIER, JOSEPH GEORGE, JR., B.S., M.S. (Rutgers), Ph.D. (Wisconsin), Associate Professor of Zoology, Milwaukee Extension Center, University of Wisconsin, *623 W. State St., Milwaukee, Wis.*

BAILEY, JOHN WENDELL, B.S., M.S. (Mississippi State), A.B., A.M. (Cornell), A.M., Ph.D. (Harvard), Professor of Biology, University of Richmond, *27 Willway Road, Richmond 21, Va.*

BAILEY, SARAH WATSON, B.S., M.S. (Middlebury), A.M., Ph.D. (Radcliffe), *15 Campden Road, Scarsdale, N. Y.*

BALAMUTH, WILLIAM, B.S. (College of the City of New York), Ph.D. (California), Assistant Professor of Zoology, *Department of Zoology, Northwestern University, Evanston, Ill.*

BALLARD, WILLIAM WHITNEY, B.S. (Dartmouth), Ph.D. (Yale), Professor of Zoology and Embryology, *Dartmouth College, Hanover, N. H.*

BALLENTINE, ROBERT, A.B., Ph.D. (Princeton), National Research Fellow in Zoology, *Rockefeller Institute for Medical Research, New York, N. Y.*

BARRETT, W(ILLIAM) C(LARK), JR., B.S., M.S. (Virginia), Ph.D. (Harvard), Assistant Professor of Histology and Embryology, *School of Medicine, Western Reserve University, Cleveland, Ohio.*

BARRY, ALEXANDER, A.B., M.A., Ph.D. (Harvard), Instructor in Anatomy, *Department of Anatomy, University of Michigan, Ann Arbor, Mich.*

BENNETT, MARY ALLISON, B.S. (Western Illinois State Teachers College), A.M., Ph.D. (Chicago), Associate Professor of Biology, *Western Illinois State Teachers College, Macomb, Ill.*

BENNINGTON, NEVILLE L(YNNE), B.A. (Wooster), M.A., Ph.D. (Northwestern), Associate Professor of Biology, *Department of Biology, Beloit College, Beloit, Wis.*

BERNARD, RICHARD, B.Sc., M.Sc. (Laval University, Quebec), Ph.D. (Cornell), Associate Director, Quebec Zoological Garden, Charlesbourg, Quebec, Instructor in Physiology, *Department of Biology, Laval University, Quebec Zoological Garden, Charlesbourg, Quebec, Canada.*

BERRY, RAYMOND ORVIL, B.S. (North Texas State Teachers College), M.S. (Agricultural and Mechanical College of Texas), Ph.D. (Johns Hopkins), Associate Geneticist, Division of Range Animal Husbandry, *Texas Agricultural Experiment Station, College Station, Texas.*

BISHOP, MABEL LOWELL, A.B. (Wellesley), A.M. (Smith), Ph.D. (Chicago), Professor of Zoology and Head of the Department, *Department of Biology, Hood College, Frederick, Md.*

BLACK, EDGAR CLARK, B.A. (McMaster), M.A. (British Columbia), Ph.D. (Pennsylvania), Research Associate, *Banting Institute, Toronto University, Toronto, Ontario, Canada.*

BLAIR, ALBERT PATRICK, B.S. (Tulsa), Ph.D. (Indiana), *Laboratory of Experimental Biology, The American Museum of Natural History, New York, N. Y.*

BLOUNT, ISABEL HARPER, A.B., M.A. (Smith), Ph.D. (Yale), Voluntary Research Worker, *Department of Anatomy, University of Minnesota, Minneapolis, Minn.*

BOCHE, ROBERT DEVORE, B.S., Ph.D. (California Institute of Technology), Instructor in Zoology, *Department of Zoology, University of Pennsylvania, Philadelphia, Pa.*

BOLING, JOHN LANDRUM, A.B. (Linfield), Ph.D. (Brown), Instructor in Anatomy, *New York University College of Medicine, 477 First Ave., New York 16, N. Y.*

BOOKHOUT, CAZLYN GREEN, A.B. (St. Stephen's), M. A. (Syracuse), Ph.D. (Duke), Assistant Professor of Zoology, *Department of Zoology, Duke University, Durham, N. C.*

BOTSFORD, E. FRANCES, B.A. (Mount Holyoke), M.S., Ph.D. (Yale), Associate Professor of Zoology, *Connecticut College, New London, Conn.*

BOWEN, R. EARL, A.B. (Hendrix College), A.M., Ph.D. (Harvard), Professor of Biology, Head of the Department of Biology, *Gettysburg College, Gettysburg, Pa.*

BOWEN, WILLIAM J., A.B., M.A. (Buffalo), Ph.D. (Johns Hopkins), *Department of Zoology, University of North Carolina, Chapel Hill, N. C.*

BREHME, KATHERINE SUYDAM, A.B. (Barnard), A.M. (Virginia), Ph.D. (Columbia), Instructor in Zoology, *Department of Zoology, Wellesley College, Wellesley, Mass.*

BRIGGS, ROBERT WILLIAM, B.S. (Boston), Ph.D. (Harvard), Biologist, *Lankenau Hospital Research Institute, Philadelphia, Pa.*

BRIGHT, WILLIAM MILTON, A.B., M.S. (Howard), Ph.D. (Illinois), Associate Professor of Biology, *Louisville Municipal College, 7th and Kentucky Sts., Louisville, Ky.*

BRYSON, VERNON, A.B. (California), M.A., Ph.D. (Columbia), Physiologist (Army contract) *Biological Laboratory, Long Island Biological Association, Cold Spring Harbor, N. Y.*

BULLOCK, THEODORE HOLMES, A.B., Ph.D. (California), Instructor in Neuroanatomy, *Department of Anatomy, Yale University School of Medicine, New Haven, Conn.*

BUNDE, CARL ALBERT, B.S., M.A., Ph.D. (Wisconsin), Assistant Professor of Physiology and Pharmacology, *Medical School, Baylor University, Dallas, Texas.*

BURBANCK, WILLIAM DUDLEY, B.A. (Earlham), M.S. (Haverford), Ph.D. (Chicago), Associate Professor of Biology and Chairman of the Department, *Department of Biology, Drury College, Springfield, Mo.*

BURDICK, HAROLD ORMOND, B.A. (Milton College), M.A. (Wisconsin), Sc.D. (Salem College), Professor of Biology, Alfred University, *17 Sayles St., Alfred, N. Y.*

BUSHNELL, RALPH JUDSON, B.S., M.S., Ph.D. (Wisconsin), Assistant Professor of Genetics, *University of Connecticut, Storrs, Conn.*

BUTLER, ELIZABETH, A.B. (Vassar), Ph.D. (Chicago), Assistant Professor of Zoology, *Vassar College, Poughkeepsie, N. Y.*

BUTT, FERDINAND HINCKLEY, A.B., M.A. (Washington), Ph.D. (Cornell), Instructor in Insect Morphology, Histology and Embryology, *Cornell University, Ithaca, N. Y.*

CABLE, LOUELLA E., A.B., A.M. (South Dakota), Associate Aquatic Biologist, *U. S. Fish and Wildlife Service, College Park, Md.*

CALDWELL, GEORGE THORNHILL, B.S. (William and Mary), S.M., Ph.D. (Chicago), Professor of Zoology, *University of Arizona, Tuscon, Ariz.*

CARLSON, LOREN DANIEL, B.S. (St. Ambrose College), Ph.D. (Iowa), Research Associate in Zoology, *Department of Zoology, State University of Iowa, Iowa City, Iowa.* (On leave for military service, '42. Captain, U. S. A.)

CARROLL, PAUL L., S.J., A.B., M.A., M.S., Ph.D. (St. Louis), Associate Professor of Biology, *St. Louis University, School of Medicine, 1402 S. Grand Blvd., St. Louis, Mo.*

CASTLE, GORDON BENJAMIN, A.B. (Wabash College), M.A., Ph.D. (California), Professor of Zoology; Chairman of the Department of Zoology, *Montana State University, Missoula, Mont.*

CHASE, ELIZABETH BROWN, A.B., A.M. (Minnesota), Ph.D. (Chicago), Guest Investigator, *Department of Zoology, University of Illinois, Urbana, Ill.*

CHASE, HYMAN YATES, B.Sc., M.Sc. (Howard), Ph.D. (Stanford), Associate Professor of Zoology, *Department of Zoology, Howard University, Washington, D. C.*

CHESTER, WEBSTER, A.B. (Colgate), A.M. (Harvard), Sc.D. (Colgate), Professor of Biology and Head of the Department, *Colby College, Waterville, Me.*

CHURNEY, LEON, A.B., Ph.D. (Pennsylvania), Instructor in Zoology, *University of Pennsylvania, Philadelphia, Pa.*

CLANCY, CLARENCE WILLIAM, B.S., M.S. (Illinois), Ph.D. (Stanford), Instructor in Zoology, *Department of Biology, University of Oregon, Eugene, Ore.*

CLARKE, L. FLOYD, B.S., M.S. (Utah State Agricultural), Ph.D. (Chicago), Associate Professor of Zoology, Director, Pre-medical Curriculum, Chairman, Department of Zoology, University of Wyoming, *Laramie, Wyo.*

COLWIN, ARTHUR LENTZ, B.Sc., M.Sc., Ph.D. (McGill), Instructor in Biology, *Queens College, Flushing, N. Y.*

COPELAND, DONALD EUGENE, A.B. (Rochester), M.A. (Amherst), Ph.D. (Harvard), Instructor in Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.* (On leave for military service, '42. 2nd Lt., U. S. A.)

CRAWFORD, STANTON CHAPMAN, A.B. (Bethany), A.M. (Cincinnati), Ph.D. (Pittsburgh), Professor of Biology and Dean of the College, University of Pittsburgh, *4744 Wallingford St., Pittsburgh 13, Pa.*

CROSMAN, ARTHUR MARSTON, B.S. (Dartmouth), A.M. (Columbia), Ph.D. (Cornell), Assistant Professor of Biology, *Washington Square College, New York University, New York, N. Y.*

CROWELL, PRINCE SEARS, JR., A.B. (Bowdoin), A.M., Ph.D. (Harvard), Assistant Professor of Zoology, *Miami University, Oxford, Ohio.*

CULBRETH, SARAH ELIZABETH, A.B., A.M., Ph.D. (Duke), Instructor in Zoology, *Department of Zoology, Duke University, Durham, N. C.*

DALTON, HOWARD CLARK, B.A., M.A. (Wesleyan), Ph.D. (Stanford), 1st Lt., U. S. A., Food and Nutrition Division, Sanitary Corps, *318 Randall Ave., Freeport, N. Y.*

D'ANGELO, SAVINO ALBERT, A.B., M.S., Ph.D. (Washington Square College), Assistant Instructor in Biology, *Washington Square College, New York University, New York City, N. Y.* (On leave for military service, '43. Lt. U. S. Army. Instructor in Aviation. High Altitude Training Unit. *MacDill Field, Tampa, Fla.)*

DANIELSON, RAGNAR NATHANAEL, B.A., M.A., Ph.D. (Minnesota), *Department of Physiology, Medical College of the State of South Carolina, Charleston 16, S. C.*

DAVENPORT, DEMOREST, A.B., Ph.D. (Harvard), M.A. (Colorado College), Assistant Professor of Biology, *Reed College, Portland, Ore.* (On leave for military service, '42. 2nd Lt., U. S. A.)

DAVID, PAUL R., M.S. (Pittsburgh), Ph.D. (Columbia), Assistant Professor of Biology, *Department of Biology, Lafayette College, Easton, Pa.*

DAY, MAXWELL FRANK COOPER, B.Sc. (Sydney, Australia), A.M., Ph.D. (Harvard), Instructor in Zoology, *Department of Zoology, Washington University, St. Louis, Mo.*

DEGENER, LYDA MAY, A.B., A.M., Ph.D. (Cornell), *"Twin Acres," Ivyland, Bucks Co., Pa.*

DELANNEY, LOUIS EDGERTON, B.A., M.A. (California), Ph.D. (Stanford), Instructor in Physiology, *San Jose State College, San Jose, Calif.*

DENNIS, EARL AUBREY, B.A. (Wooster), Ph.D. (Chicago), Professor of Biology, *American University, Washington, D. C.*

DERBYSHIRE, RUSSEL CLAY, B.Sc., M.Sc. (Kansas State), Ph.D. (Iowa State), Instructor in Zoology and Comparative Anatomy, *University of Omaha, Omaha, Nebr.*

DERICKSON, SAMUEL HOFFMAN, B.S., M.S., S.D. (Lebanon Valley), Professor of Biological Science and Head of the Department, *Tyrone Biological Laboratory, Lebanon Valley College, Annville, Pa.*

DILDINE, GLENN C(RAWFORD), A.B. (De Pauw), M.S., Ph.D. (Northwestern), Chairman, Division of Science and Mathematics, *State Teachers College, Moorhead, Minn.*

DOBROVOLNY, CHARLES GEORGE, A.B. (Montana), M.S. (Kansas State College), Ph.D. (Michigan), Assistant Professor, Department of Zoology, *University of New Hampshire, Durham, N. H.*

Dornfeld, Ernst John, B.S. (Marquette), M.A., Ph.D. (Wisconsin), Assistant Professor of Zoology, *Department of Zoology, Oregon State College, Corvallis, Ore.*

Driver, Ernest Charles, Ph.D. (Illinois), Associate Professor of Zoology, Smith College, *Northampton, Mass.*

Dropkin, Victor H., B.A. (Cornell), Ph.D. (Chicago), Instructor in Zoology in The College, *The University of Chicago, Chicago 37, Ill.* (On leave for military service, '43. 2nd Lt. Sanitary Corps.)

Drury, Horace Featherstone, B.S. (George Washington), A.M., Ph.D. (Harvard), Tutor in Biology, *Brooklyn College, Brooklyn, N. Y.* (On leave for military service, '43. *Lt. A. C. Altitude Training Unit, Army Air Base, Ephrata, Wash.)*

Dugal, Louis Paul, B.A., M.A., M.Sc. (Laval), Ph.D. (Pennsylvania), Professeur agrégé de Physiologie générale, Université de Montréal, *2806 Maplewood, Montreal, Quebec, Canada.*

Dunham, H(enry) Howard, B.S. (Kansas State Teachers), Sc.M., Ph.D. (Brown), Assistant Instructor, *Department of Anatomy, The University of Kansas, Lawrence, Kan.*

Dunkle, David Hosbrook, A.B. (Kansas), Ph.D. (Harvard), Assistant in charge of paleontology, *Department of Paleontology, Cleveland Museum of Natural History, 2717 Euclid Ave., Cleveland, Ohio.*

Duryee, William Rankin, B.A., Ph.D. (Yale), Capt., Medical Administration Corps, Instructor, School for Medical Department Technicians, *Fitzsimons General Hospital, Denver, Colo.*

Eaton, Orson Northrop, B.S. (Cornell), M.S., Ph.D. (Maryland), Associate Animal Husbandman, *19 Clagett Rd., University Park, Hyattsville, Md.*

Eddy, Milton W., B.S., M.S. (Northwestern), Ph.D. (Pennsylvania), Professor of Biology, Dickinson College, *249 W. Louther St., Carlisle, Pa.*

Edmondson, W(alles) T(homas,) B.S., Ph.D. (Yale), *Woods Hole Oceanographic Institute, Woods Hole, Mass.*

Eigenbrodt, Harold John, B.A. (North Central), M.A., Ph.D. (Illinois), Professor of Zoology, North Central College, *631 E. North Ave., Naperville, Ill.*

Eisenbrandt, Leslie Lee, A.B. (College of Emporia), M.S. (Kansas State), Ph.D. (Rutgers), Assistant Professor of Physiology, Director of Research, *University of Kansas City, School of Dentistry, 10th and Troost Ave., Kansas City, Mo.*

Emerson, Henry Seelye ,A.M. (Amherst), Ph.D. (Yale), Assistant Professor of Biology, Amherst College, *58 Seelye St., Amherst, Mass.*

Evans, Francis Gaynor, B.A. (Coe College), M.A., Ph.D. (Columbia), Instructor in Zoology, *University of New Hampshire, Durham, N. H.*

Farner, Donald S(ankey), B.S. (Hamline), M.A., Ph.D. (Wisconsin), Instructor in Zoology, University of Wisconsin. (On leave for military service, '43. Ensign H-V (S), USNR, Specialist in Medical Department, *4926 Cass St., Omaha 3, Nebr. c/o C. S. Copps.)*

Fish, Harold Somers, A.B. (Bowdoin), Ph.D. (Harvard), Professor of Biology, *Presbyterian College, Clinton, S. C.*

Flynn, Carl Munro, A.B. (Maine), M.A. (Wesleyan), M.A., Ph.D. (Harvard), Instructor in Zoology, *University of Maine, Orono, Me.*

Forbes, Grace Springer, A.B., A.M. (Oberlin), Ph.D. (Columbia), Instructor in Zoology, *Barnard College, Columbia University, New York, N. Y.*

Foster, Kendall Wilson, B.S. (Tufts), A.M., Ph.D. (Harvard), *Bennett Junior College, Millbrook, N. Y.*

Foster, Mark A., A.B. (Louisiana Normal), M.S. (Kansas State Agric. College), Ph.D. (Wisconsin), M.D. (Harvard), Fellow in Medicine, *Mayo Clinic, Rochester, Minn.* (On leave for military service, '42. Lt. (jg), U. S. N. R. *6662 Hillandale Road, Bethesda, Md.)*

Foulks, James Grigsby, B.A. (Rice), Ph.D. (New York), Instructor in Anatomy, Ohio State University. (On leave for military service, '43. 2nd Lt., A.C., Aviation Physiologist, *34th Altitude Training Unit, AAB Bolling Field, D. C.)*

Frizzell, Harriet Exline, A.B. (Reed), M.S., Ph.D. (Washington), *Apartodo 803, c/o International Petroleum Company, Guayaquil, Ecuador, South America.*

Fry, Frederick Ernest Joseph, M.A., Ph.D. (Toronto), Lecturer and Research Assistant, *Department of Biology, University of Toronto, Toronto, Canada.*

Fuller, John Langworthy, B.S. (Bates), Ph.D. (Massachusetts Institute of Technology), Assistant Professor of Zoology, *25 Coburn Hall, University of Maine, Orono, Me.*

Furrow, Clarence Lee, A.B., A.M., (Oklahoma), Ph.D. (Iowa), Professor of Biology, *Knox College, Galesburg, Ill.*

Gatz, Arthur John, B.A. (Carleton), M.A., Ph.D. (Minnesota), Assistant Professor of Anatomy, *Loyola University School of Medicine, 706 So. Wolcott, Chicago 12, Ill.*

Gayer, H. Kenneth, A.B. (Oberlin), Ph.D. (Washington), Special Lecturer in Physics and Instructor in Zoology, *Department of Biology, Grinnell College, Grinnell, Iowa.*

Gier, Herschel T., A.B. (Kansas State Teachers), Ph.D. (Indiana), Assistant Professor of Zoology, *Ohio University, Athens, Ohio.*

Gilbert, Perry Webster, A.B. (Dartmouth), Ph.D. (Cornell), Assistant Professor of Zoology, *Department of Zoology, Cornell University, Stimson Hall, Ithaca, N. Y.*

Goodchild, Chauncey G., B.S. (Westminster College), Ph.D. (New York), Assistant Professor of Biology, *Department of Biology, Southwest Missouri State Teachers College, Springfield, Mo.*

Grant, Ronald, B.Sc. (London), Ph.D. (Edinburgh), Lecturer in Zoology, McGill University, *Department of Zoology, McGill University, Montreal, Quebec, Canada.*

Gray, Stephen Wood, A.B. (Lake Forest), M.A., Ph.D. (Illinois), Instructor in Physiology, *427 Natural History Building, University of Illinois, Urbana, Ill.*

Green, Earl Leroy, B.S. (Allegheny College), Sc.M., Ph.D. (Brown), Instructor in Zoology, *Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio.* (On leave for military service, '43, 2nd Lt. U. S. A. Air Force.)

Green, Elizabeth Ufford (Mrs. Louis Craig Green), A.B., M.A., Ph.D. (Bryn Mawr), Part-time Instructor in Biology, *Bryn Mawr College, Dalton Hall, Bryn Mawr, Pa.*

GREGG, ROBERT E., S.B., Ph.D. (Chicago), Instructor in Zoology, *Department of Biology, State Teachers College, Duluth, Minn.*

GROBMAN, ARNOLD BRAMS, B.S. (Michigan), M.S., Ph.D. (Rochester), Instructor in Zoology, *Biological Laboratories, University of Rochester, Rochester, N. Y.*

GROBSTEIN, CLIFFORD, B.S. (College of the City of New York), M.S., Ph.D. (California), Instructor in Zoology, *Department of Zoology, Oregon State College, Corvallis, Ore.*

GUHL, ALPHAEUS MATTHEW, B.A. (North Central College), M.S., Ph.D., (Chicago), Instructor in Zoology, *Department of Zoology, Kansas State College, Manhattan, Kan.*

HADIDIAN, ZAREH, B.S., M.S. (Rensselaer), Ph.D. (Clark), Instructor in Biology, *Clark University, Worcester, Mass.*

HAGQUIST, CARL WALDEMAR, Ph.B., Ph.D. (Brown), *Carolina Biological Supply Company, Elon College, N. C.*

HALL, B(ENJAMIN) VINCENT, A.B. (Linfield), Ph.D. (Yale), Assistant Professor of Zoology, University of Illinois, *Natural History Building, Urbana, Ill.*

HALL, SAM RUTHERFORD, A.B. (Washington and Lee), A.M., Ph.D. (Virginia), *Bureau of Dairy Industry, U. S. Department of Agriculture, Beltsville, Md.*

HAMMOND, DATUS MILLER, B.S. (Utah State Agricultural College), M.A., Ph.D. (California), Associate Protozoologist, *U. S. Regional Laboratory for Animal Disease Research, Auburn, Ala.*

HANSBOROUGH, LOUIS ARMSTEAD, S.B. (Harvard), M.S. (Chicago), Ph.D. (Harvard), Assistant Professor of Zoology, *Howard University, Washington, D. C.*

HANSEN, IRA BOWERS, B.S., M.A. (Wesleyan), Ph.D. (Chicago), Associate Professor of Zoology, *Department of Zoology, George Washington University, Washington, D. C.*

HARDCASTLE, AARON BASCOM, B.A., M.A. (Richmond), Ph.D. (Duke), Parasitologist, *U. S. Bureau of Animal Industry, Research Center, Beltsville, Md.*

HARMAN, PINCKNEY JONES, B.S., M.S. (Georgetown), Ph.D. (Yale), Instructor in Anatomy, *Department of Anatomy, Georgetown University, School of Medicine, Washington, D. C.*

HAUBER, ULRICH ALBERT, A.B. (St. Ambrose), M.A. (Catholic), Ph.D. (Iowa), Professor of Biology, *St. Ambrose College, Davenport, Iowa.*

HAUSCHKA, THEODORE SPAETH, A.B. (Princeton), M.S., Ph.D. (Pennsylvania), Research Fellow in Biology, *Lankenau Hospital Research Institute, Girard and Corinthian Aves., Philadelphia, Pa.*

HEFLEY, HAROLD MARTIN, B.S., M.S., Ph.D. (Oklahoma), Medical Technician, *400 N.W. 10th St., Oklahoma City, Okla.*

HENDEE, ESTHER C., A.B. (Oberlin), Ph.D. (California), Associate Professor of Biology, *Russell Sage College, Troy, N. Y.*

HETHERINGTON, WILLIAM ALFORD, A.B., M.A. (Columbia), Ph.D. (Stanford), Assistant Professor of Physiology, *University of Oklahoma, Norman, Okla.*

HEWITT, WILLIAM FRANCIS, JR., A.B. (Princeton), S.M., Ph.D. (Chicago), Assistant Professor of Zoology, *Department of Zoology, University of Wichita, Wichita, Kan.*

HIGBEE, EDNA, B.S., M.S., Ph.D. (Pittsburgh), Pharmaceutical Chemist, *2845 Broadway Avenue, South Hills Station, Pittsburgh, Pa.*

HITCHCOCK, HAROLD BRADFORD, B.A. (Williams College), M.A., Ph.D. (Harvard), Assistant Professor of Biology, *Middlebury College, Middlebury, Vt.*

HOLT, VESTA, A.B. (Oregon), M.A. (Columbia), Ph.D. (Stanford), Professor of Biological Sciences and Head of the Department, *Chico State College, Chico, Calif.*

HORN, EDWARD CHARLES, B.S. (Trinity College), A.M., Ph.D. (Princeton), Instructor in Zoology, *Department of Zoology, University of Arizona, Tucson, Ariz.* (On leave for military service, '43, 2nd Lt. U. S. A. Air Force, Aviation Physiologist, *1316 East First Street.)*

HOROWITZ, NORMAN H., B.S. (Pittsburgh), Ph.D. (California Institute of Technology), Research Associate in Biology, *Department of Biology, Stanford University, Calif.*

HOWELL, CHARLES DEWITT, A.B. (Oberlin), Ph.D. (Johns Hopkins), Assistant Professor of Zoology, *Department of Biology, University of Rochester, Rochester, N. Y.*

HSIAO, SIDNEY CHIH TI, B.A. (Shanghai), M.S. (Yenching), Ph.D. (Harvard), *Department of Biology, Hua Chung College, Hsichow Uil Tali, Yunnan, China.*

HUGGINS, RUSSELL ARNO, B.S. (Aurora College), Ph.D. (Western Reserve), Instructor in Biology, *Department of Biology, Eastern State Teachers College, Madison, S. D.*

HULPIEU, HAROLD RAYMOND, A.B. (Southwestern), M.A. (Oklahoma), Ph.D. (Johns Hopkins), Associate Professor, Department of Pharmacology, *Indiana University School of Medicine, Indianapolis, Ind.*

HUNTER, WANDA SANBORN, B.A. (Wisconsin), M.S. (Illinois), Ph.D. (California, Los Angeles), Assistant Professor of Zoology, *Department of Zoology, University of Arizona, Tuscon, Ariz.*

INGLE, LESTER, B.S. (Kansas State Teachers College), M.S., Ph.D. (Brown), Associate in Zoology, *Department of Zoology, 300 Natural History Building, University of Illinois, Urbana, Ill.*

JOHNSON, DAVID F., B.A. (Wabash), M.S., Ph.D. (New York), Assistant Professor of Biology, *Southern College, Lakeland, Fla.*

JOHNSON, J. GARTH, B.A. (Drake), M.S., Ph.D. (Iowa), Senior Serologist-Bacteriologist, Iowa State Department of Health, *Department of Hygiene and Preventive Medicine, Medical Laboratories, State University of Iowa, Iowa City, Iowa.*

JOHNSON, LELAND PARRISH, B.S. (Monmouth College), M.S., Ph.D. (Iowa State), Associate Professor of Biology, *Department of Biology, Drake University, Des Moines, Iowa.*

JOHNSON, MAYNARD STICKNEY, A.B. (Bates), A.M., Ph.D. (Illinois), Associate Wildlife Technician, National Park Service, U. S. Department of Interior, *39 Summer St., Saugus, Mass.*

JOHNSON, MYCHYLE WELLINGTON, A.B. (Indiana Central), Ph.D. (Indiana), Assistant Professor of Zoology, *Department of Zoology, Duke University, Durham, N. C.*

JONES, EDGAR PERCIVAL, B.S., M.S., Ph.D. (Pittsburgh), Associate Professor, Department of Biology, *University of Akron, Akron, Ohio.*

Jones, Roy Winfield, A.B. (Oklahoma City University), M.S. (Kansas State), Ph.D. (Oklahoma), Professor of Biology and Dean, *Central State College, Edmond, Okla.*

Kaliss, Nathan, B.S. (College of the City of New York), M.A., Ph.D. (Columbia), Research Assistant in Pathology, *Department of Pathology, Cornell University, York Ave. and 69th St., New York, N. Y.*

Kaplan, Harold M., A.B. (Dartmouth), A.M., Ph.D. (Harvard), Professor of Physiology, *Department of Physiology, Middlesex University, Waltham, Mass.*

Katzin, Leonard Isaac, A.B. (California, Los Angeles), Ph.D. (California, Berkeley), Assistant Biologist, *United States Public Health Service, 300 Essex Building, Bank and Plume Sts., Norfolk, Va.*

Kavanagh, Virgene Warbritton, A.B., A.M., Ph.D., B.S. in Ed. (Missouri), Assistant, *New York Botanical Garden, Bronx, N. Y.*

Kaylor, Cornelius Timpson, A.B. (Wesleyan), M.S. (Rutgers), Ph.D. (Princeton), Instructor in Anatomy, *Medical College, Syracuse University, Syracuse, N. Y.*

Keck, Warren N., B.A., M.S., Ph.D. (Iowa), Associate Professor of Biology, *Department of Biology, Coe College, Cedar Rapids, Iowa.*

Kelsall, Margaret Aston, B.A., M.A., Ph.D. (Colorado), Research Associate and Biologist in Charge of the Hamilton Station, *Hamilton Station, Salsbury Cove, Me.*

Kent, George Cantine, Jr., B.A. (Maryville), M.A., Ph.D. (Vanderbilt), Instructor in Zoology, *Department of Zoology, Louisiana State University, University Station, Baton Rouge, La.*

Kitchin, Irwin Clark, B.S. (Wake Forest), Ph.D. (Freiburg), Instructor in Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.* (On leave for military service, '42. Lt. (j.g.) U. S. N. R.)

Kopenhaver, Mary Elizabeth, A.B. (Hood), M.A., Ph.D. (Northwestern), Instructor in Biology, *Lake Forest College, Lake Forest, Ill.*

Kraatz, Walter Charles, B.A. (Wisconsin), M.A., Ph.D. (Ohio State), Professor of Biology, *University of Akron, Akron, Ohio.*

Laidlaw, Harry H., Jr., B.S., M.S. (Louisiana), Ph.D. (Wisconsin), *State Apiarist, Montgomery, Ala.* (On leave for military service, '43, *2nd Lt. Medical Administrative Corps, U. S. A. Station Hospital, S. A. A. F., Stuttgart, Ark.)*

Lamar, Jule Kitchell, B.S. (Birmingham-Southern College), Ph.D. (Chicago), Assistant Professor in Obstetrics and Gynecology, *The University of Texas, Medical Branch, Galveston, Texas.*

Lane, Charles Edward, B.A., M.A., Ph.D. (Wisconsin), Assistant Professor of Zoology, *University of Wichita, Wichita, Kan.*

Leonard, Arthur Byron, B.A. (Central State Teachers), M.A., Ph.D. (Kansas), Assistant Professor of Anatomy and Zoology, *Department of Zoology, University of Kansas, Lawrence, Kan.*

Leslie, Lawrence Dale, B.A., M.A. (Oregon), Ph.D. (Stanford), Associate Professor of Zoology, *San Jose State College, San Jose, Calif.*

Levenstein, Irving Max, A.B., M.S., Ph.D. (New York), *Leberco Laboratories, Bloomfield, N. J.*

Libby, Raymond Loring, B.S., M.S., Ph.D. (Rutgers), Biophysicist, *American Cyanimide Company, Stamford, Conn.*

LIPSETT, JAMES CONLEY, B.S. (Lafayette), Ph.D. (Yale), Assistant Professor of Anatomy, *Department of Anatomy, University of Maryland, Baltimore, Md.*

LIGHT, V. EARL, A.B., M.S. (Lebanon Valley), Ph.D. (Johns Hopkins), Associate Professor of Biology, *Lebanon Valley College, R. No. 1, Annville, Pa.*

LOCHHEAD, JOHN HUTCHISON, M.A. (St. Andrews, Scotland), B.A., Ph.D. (Cambridge), Instructor in Zoology, *Department of Zoology, University of Vermont, Burlington, Vt.*

LOVELL, HARVEY BULFINCH, A.B. (Bowdoin), A.M., Ph.D. (Harvard), Associate Professor of Zoology, *Biology Department, University of Louisville, Louisville, Ky.*

LOWRANCE, EDWARD WALTON, A.B., A.M. (Utah), Ph.D. (Stanford), Associate Professor of Zoology, *Department of Biology, University of Nevada, Reno, Nev.*

LOWRIE, DONALD C., B.S., Ph.D. (Chicago), Assistant Curator of Zoology and Museum Preparator, *Chicago Academy of Sciences, 2001 N. Clark St., Chicago, Ill.*

MACCARDLE, ROSS C(LAYTON), B.S. (Michigan), Ph.D. (Brown), Instructor and Research Associate, Department of Anatomy, *Washington University School of Medicine, St. Louis, Mo.* (On leave for military service, '42. Capt., A.C., U. S. A. Air Force, Aero Medical Laboratory, Wright Field, Dayton, Ohio.

MAGRUDER, SAMUEL ROSSINGTON, B.S. (Kentucky), M.A., Ph.D. (Cincinnati), Assistant Professor of Anatomy, *Department of Anatomy, Tufts College Medical School, Boston, Mass.*

MARKUS, HENRY C., Ed.B. (Southern Illinois State Teachers), M.S. (Illinois), Assistant Aquatic Biologist, U. S. Bureau of Fisheries, *Museum of Arts and Sciences, Edgerton Park, Rochester, N. Y.*

MARVIN, HORACE NEWELL, B.A. (Morningside College), M.A., Ph.D. (Wisconsin), Instructor in Anatomy, *Department of Anatomy, School of Medicine, University of Arkansas, Little Rock, Ark.*

MCNUTT, CLARENCE WALLACE, B.A. (Henderson State College), M.S. (Louisiana), Ph.D. (Brown), Muellhaupt Fellowship, Ohio State University, *141 W. 11th Ave., Columbus, Ohio.* (On leave for military service, '42. U. S. A. Air Force.)

MEGLITSCH, PAUL ALLEN, B.S., M.S., Ph.D. (Illinois), Instructor in Zoology, *Wright Junior College, Chicago, Ill.*

MILLER, E. DEWITT, A.B. (Bridgewater), M.A. Ph.D. (Virginia), Associate Professor of Biology, *Box 388, Madison College, Harrisonburg, Va.*

MILLER, EDWIN LYNN, B.S. (Iowa Wesleyan), M.S., Ph.D. (Illinois), Associate Professor of Biology, *Department of Biology, Lawrence College, Appleton, Wis.*

MILLER, ELWOOD MORTON, B.S. (Bethany), M.S., Ph.D. (Chicago), Associate Professor of Zoology, *Department of Zoology, University of Miami, Coral Gables, Fla.*

MILLER, RICHARD AVERY, A.B. (Pittsburgh), M.S., Ph.D. (Iowa), Cytologist, *Station for Experimental Evolution, Carnegie Institution of Washington, Cold Spring Harbor, Long Island, N. Y.*

Miller, Roland E., B.S., M.S. (Pittsburgh), Ph.D. (Missouri), Assistant Professor of Anatomy, *Bowman Gray School of Medicine, Wake Forest College, Winston-Salem, N. C.*

Mohr, John Luther, A.B. (Bucknell), Ph.D. (California), Research Associate in Zoology, Department of Zoology, University of California, Berkley, and Research Associate in Tropical Diseases Survey, *Hoover Research Institute, Stanford University, Calif.*

Moment, Gairdner Bostwick, A.B. (Princeton), Ph.D. (Yale), Associate Professor of Biology, *Department of Biology, Goucher College, Baltimore, Md.*

Moody, Paul Amos, A.B. (Morningside), Ph.D. (Michigan), Associate Professor of Zoology and Director of Graduate Study, *Department of Zoology, University of Vermont, Burlington, Vt.*

Moreland, George Edward, A.B. (Greenville), M.S. (Michigan), Ph.D. (Cornell), Professor of Biology, Chairman, Division of Science and Mathematics and Director of the Summer Session, *Houghton College, Houghton, N. Y.*

Morgan, Charles Frederick, A.B. (Wichita), Ph.D. (Chicago), Assistant Professor of Pharmacology and Materia Medica and Professor and Chairman of the Department of Dental Pharmacology, *Department of Pharmacology, Georgetown University School of Medicine, Washington, D. C.*

Moritz, Charles Edgar, A.B. (Dartmouth), Ph.D. (California), Instructor, *Department of Zoology, Dartmouth College, Hanover, N. H.*

Myers, Hugh I(rvin), B.A., (Mississippi), M.A. (Richmond), Ph.D. (Brown), Assistant Professor of Zoology, University of Richmond, *Box 107, University of Richmond, Va.* (On leave for military service, '43, *1st Lt. U. S. A. Air Force, Aviation Physiologist, Randolph Field, San Antonio, Texas.)*

Myers, Raymond J., A.B. (Heidelberg), Ph.D. (Pennsylvania), Instructor, *Department of Zoology, Colgate University, Hamilton, N. Y.*

Nahm, Laura Julia, B.S. in Ed., A.B., A.M., Ph.D. (Missouri), Professor of Biology, *Flat River Junior College, Flat River, Mo.*

Neave, Ferris, B.Sc., M.Sc. (Manchester), Assistant Biologist, Fisheries Research Board of Canada, *Pacific Biological Station, Nanaimo, British Columbia, Canada.*

Nester, Henry George, A.B. (Butler), A.M., Ph.D. (Indiana), Professor and Head of the *Department of Physiology and Health, Butler University, Indianapolis, Ind.*

Noble, Elmer R., A.B., M.A., Ph.D. (California), Associate Professor of Biology, *State College, Santa Barbara, Calif.*

Noble, Glenn Arthur, A.B., M.A. (California), Ph.D. (Stanford), Department of Zoology, *San Francisco Junior College, Ocean and Phelan Ave., San Francisco, Calif.*

Norris, Charles H., B.S. (Hamilton), Ph.D. (Princeton), Assistant Professor of Biology, *Department of Biology, University of Colorado, Boulder, Colo.*

Novikoff, Alex Benjamin, B.S., M.A., Ph.D. (Columbia), Instructor, *Biology Department, Brooklyn College, Ave. H. and Bedford Ave., Brooklyn, N. Y.*

Nunnemacher, Rudolph Fink, B.S. (Kenyon), M.A., Ph.D. (Harvard), Assistant Professor of Biology, *Clark University, Worcester, Mass.*

O'BRIEN, JOHN PATRICK, B.S. (Illinois), Ph.D. (Johns Hopkins), Assistant Professor of Zoology, *Department of Zoology, Mercy College, 8200 W. Outer Drive, Detroit, Mich.*

ODIORNE, JOSEPH MILTON, B.S. (Bowdoin), A.M., Ph.D. (Harvard), Assistant Professor of Anatomy, *Department of Anatomy, Georgetown University School of Medicine, Washington, D. C.*

OLIPHANT, JOSEPH F(REDERICK), A.B. (Wabash), Ph.D. (Johns Hopkins), Assistant Professor of Biology, *Stanford University, Stanford University, Calif.*

OLSON, MAGNUS, B.A. (St. Olaf), M.A., Ph.D. (Minnesota), Instructor in Zoology, *Department of Zoology, University of Minnesota, Minneapolis, Minn.*

OSTERUD, HJALMAR LAURITZ, A.B., A.M. (Washington), Ph.D. (Minnesota), Professor of Anatomy and Head of the Department, *Medical College of Virginia, Richmond, Va.*

OWEN, BRADFORD BRECKENRIDGE, B.A., M.A. (Williams College), M.A., Ph.D. (Harvard), Instructor in Biology, *Long Island University, Brooklyn, N. Y.*

PAINTER, BEN THOMAS, B.S. (William and Mary), M.A., Ph.D. (Harvard), Instructor in Biology, *Armstrong Junior College, Savannah, Ga.*

PEARSON, JAY FREDERICK WESLEY, B.S., M.S. (Pittsburgh), Ph.D. (Chicago), Professor of Zoology and Dean of Administration, University of Miami, *321 S.W. 32 Rd., Miami, Fla.* (On leave for military service, '42. Capt., U. S. A. Air Force.)

PEASE, DANIEL CHAPIN, A.B. (Yale), M.S. (California Institute of Technology), Ph.D. (Princeton), *Department of Biology, Stanford University, Hopkins Marine Station, Pacific Grove, Calif.*

PERROT, MAX, Ph.D. (Geneva), Instructor in Zoology, *University of Missouri, Columbia, Mo.*

PHELPS, LILLIAN ALINE, A.B., M.A. (Kansas), Ph.D. (Cornell), Substitute teacher at Hunter College in Biology, *276 W. 71st St., Apartment No. 1, New York, N. Y.*

PIERCE, MADELENE EVANS, A.B., A.M., Ph.D. (Radcliffe), Assistant Professor of Zoology, *Vassar College, Poughkeepsie, N. Y.*

POLLISTER, PRISCILLA F., A.B. (Bates) A.M., Ph.D. (Columbia), Assistant Professor of Biology, *Department of Biology, Brooklyn College, Bedford Ave. and Ave. H., Brooklyn, N. Y.*

POMERAT, GERARD ROLAND, A.B. (Clark), A.M., Ph.D. (Harvard), Instructor in Biology, Biological Laboratories, *Harvard University, Cambridge, Mass.*

PORTER, KEITH ROBERTS, B.Sc. (Acadia), A.M., Ph.D. (Harvard), Research Assistant, *Rockefeller Institute, New York, N. Y.*

QUIRING, DANIEL PAUL, A.B. (Oberlin), M.A. (Illinois), Ph.D. (Western Reserve), Associate Professor of Biology, *Western Reserve University, Cleveland, Ohio.*

RABINOWITZ, MORRIS, B.S. (College of City of New York), Sc.M., Ph.D. (New York), Laboratory Assistant, *77-35 113th St., Forest Hills, Queens, N. Y.*

RANDALL, WALTER CLARK, B.A. (Taylor), M.S., Ph.D. (Purdue), Fellow in Physiology, *Western Reserve University, School of Medicine, Cleveland, Ohio.*

RAY, OVID MALCOLM, B.A., M.A. (Drake), Ph.D. (Iowa), Assistant Professor of Physiology and Zoology, *North Dakota Agricultural College, Fargo, N. D.*

RENSHAW, BIRDSEY, S.B., M.A., Ph.D. (Harvard), Assistant Professor, *Wright Laboratory, Oberlin College, Oberlin, Ohio.*

RICE, NOLAN ERNEST, A.B. (Kentucky), A.M., Ph.D. (Duke), *Head of Culture Department, Carolina Biological Supply Company, Elon College, N. C.*

RIS, HANS, Ph.D. (Columbia), Instructor in Biology, *Department of Biology, The Johns Hopkins University, Baltimore 18, Md.*

ROBERTSON, CHARLES WILLIAM, B.S. (Southwestern), M.S., Ph.D. (New York), Professor of Biology, *Eureka College, Eureka, Ill.*

ROBESON, JOHN MAXWELL, B.S., M.S., Ph.D. (Virginia), Associate Professor of Zoology, *Department of Zoology, Syracuse University, Syracuse, N. Y.*

ROBINSON, TRUE WILLIAM, B.S. (California Institute of Technology), M.A., Ph.D. (Harvard), Associate in Zoology, *345 Natural History Building, University of Illinois, Urbana, Ill.* (On leave for military service, '43, *2nd Lt. U. S. A. Air Force, Aviation Physiologist, Aero Medical Laboratory, Wright Field, Ohio.)*

ROEDER, KENNETH DAVID, B.A., M.A. (Cambridge, England), Assistant Professor of Biology, *Tufts College, Medford, Mass.*

ROGERS, PHILIP V., A.B., A.M. (Hamilton), Ph.D. (Yale), Assistant Professor of Biology, *Hamilton College, Clinton, N. Y.*

ROOSEN-RUNGE, EDWARD C., Dr.med. (Hamburg), *Photographic Laboratory, Brown University, Providence, R. I.*

ROOT, CLINTON WILLIAM, A.B., A.M. (Oberlin), Ph.D. (Princeton), Assistant Professor of Zoology, *Lyman Hall, Syracuse University, Syracuse, N. Y.*

ROSE, S(YLVAN) MERYL, B.A., M.A. (Amherst), Ph.D. (Columbia), Instructor in Zoology, *Department of Zoology, Smith College, Northampton, Mass.*

RUBIN, DAVID, B.S., Ph.D. (Chicago), *Department of Zoology, The University of Chicago, Chicago 37, Ill.*

RUEBUSH, TRENTON KIEFFER, A.B. (Bridgewater), A.M., Ph.D. (Virginia), Staff, *Naval Medical School, Naval Medical Center, Washington, D. C.*

RUSSELL, WILLIAM LAWSON, A.B. (Oxford), Ph.D. (Chicago), Research Associate, *Jackson Memorial Laboratory, Bar Harbor, Me.*

RYAN, FRANCIS JOSEPH, A.B., M.A., Ph.D. (Columbia), Instructor in Zoology, *Department of Zoology, Columbia University, New York, N. Y.*

SANFORD, KATHERINE KOONTZ, A.B. (Wellesley), M.A., Ph.D. (Brown), Instructor in Biology, Department of Biology, *Allegheny College, Meadville, Pa.*

SAWIN, HORACE JOHN, A.B. (Earlham College), A.M., Ph.D. (Harvard), Research Consultant in Paleontology, *State Museum, 1904 San Gabriel Ave., Austin, Texas.*

SAWYER, ELIZABETH LOUISE, A.B. (Maine), A.M. (Michigan), Ph.D. (Missouri), Associate Professor of Biology, *Department of Biology, Rockford College, Rockford, Ill.*

SCHARRER, BERTA (Mrs. E. Scharrer), Ph.D. (Universtiy of Munich), Senior Instructor in Anatomy, *Department of Anatomy, Western Reserve University, Cleveland, Ohio.*

SCHELL, MARGARET WOOD, A.B., M.A., Ph.D. (California), Assistant Professor of Zoology, *University of Utah, Salt Lake City, Utah.*

SCHMIEDER, RUDOLF GUSTAV, A.B., A.M., Ph.D. (Pennsylvania), Assistant Professor of Zoology, *Zoological Laboratory, University of Pennsylvania, Philadelphia, Pa.*

SCHOENBORN, HENRY WILLIAM, A.B. (DePauw), Ph.D. (New York), *Department of Biology, Stanford University, Stanford University, Calif.* (On leave for military service, '43, U. S. A.)

SCOTT, SISTER FLORENCE MARIE, A.B. (Seton Hill), M.A., Ph.D. (Columbia), Professor of Biology, *Seton Hill College, Greensburg, Pa.*

SCOTT, JOHN PAUL, A.B. (Wyoming), B.A. (Oxford), Ph.D. (Chicago), Professor of Zoology; Head of the Department of Zoology, *Wabash College, Crawfordsville, Ind.*

SCOTT, WALTER JAMES, Ph.B. (Lafayette), Ph.D. (Pennsylvania), Associate Professor of Zoology, *Swarthmore College, Swarthmore, Pa.*

SHAFTESBURY, ARCHIE D., A.B. (Southwestern), Ph.D. (Johns Hopkins), Associate Professor of Zoology, *Woman's College of the University of North Carolina, Greensboro, N. C.*

SHLAER, SIMON, A.B., M.A., Ph.D. (Columbia), *Laboratory of Biophysics, Columbia University, New York, N. Y.*

SHLAIFER, ARTHUR, S.B. (College of the City of New York), S.M., Ph.D. (Chicago), Research Associate, Laboratory of Experimental Biology, *American Museum of Natural History, New York, N. Y.* (On leave, Sanitarian, U. S. Public Health Service, Tennessee Dept. L., Public Health, Nashville, Tenn.)

SHOEMAKER, HURST H., A.B. (Earlham), Ph.D. (Chicago), Instructor in Zoology, University of Illinois, *Vivarium Building, Wright and Healey Sts., Champaign, Ill.*

SICHEL, ELSA KEIL, B.S. (Elmira), M.A. (Brown), Head of the Biology Department, *Trinity College, Burlington, Vt.*

SIMMONS, GEORGE, FINLAY, B.A., M.A. (Texas), Ph.D. (Chicago), Assistant Professor of Anatomy, *Loyola University School of Medicine, 706 S. Wolcott Ave., Chicago 12, Ill.*

SMITH, CHARLES CLINTON, B.S. (Central State Teachers' College, Oklahoma), M.S., Ph.D. (Oklahoma), Work Unit Leader in Charge of District, U. S. Soil Conservation Service, *c/o Soil Conservation Service, Alice, Texas.*

SMITH, FREDERICK GEORGE WALTON, B.Sc., Ph.D. (London), A.R.C.S. (Royal College of Science), Assistant Professor of Zoology, *Department of Zoology, University of Florida, Coral Gables, Fla.*

SOLINGER, JULIAN L., Ph.B., Sc.M., Ph.D. (Brown), B.Ed. (Rhode Island College of Education), Assistant Professor of Biology, *Simmons College, 300 The Fenway, Boston, Mass.*

SONNENBLICK, BENJAMIN P., B.S. (College of City of New York), M.S., Ph.D. (New York), Associate in Biology, *Department of Biology, Queens College, Flushing, N. Y.*

SPIETH, HERMAN T., A.B. (Indiana Central), Ph.D. (Indiana), Assistant Professor of Zoology, *Biology Department, College of the City of New York, 139th St. and Convent Ave., New York, N. Y.*

SPOOR, WILLIAM ARTHUR, *B.S.* (Washington), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Department of Zoology, University of Cincinnati, Cincinnati, Ohio.*

Spotkov, Elias Morlenn, B.S. (College of City of New York), M.S., Ph.D. (New York), *U. S. Office of Censorship, 120 E. Myrtle St., San Antonio, Texas.*

Sprague, Victor, B.Ed. (Southern Illinois State Normal), M.S., Ph.D. (Illinois), Instructor in Zoology and Bacteriology, *Marshall College, Huntington, W. Va.*

Stanley, Allan John, A.B. (Simpson), M.S., Ph.D. (Iowa), Instructor in Physiology, *Department of Physiology, Oklahoma Medical School, Oklahoma City, Okla.*

Steffens, Herman Walter, B.S., M.S. (Idaho), Ph.D. (Harvard), Assistant Professor of Zoology, and Acting Head of Department of Zoology, *University of Idaho, Moscow, Idaho.*

Street, Sibyl Fawcett (Mrs. Robert Ramsey), A.B. (Vassar), Ph.D. (Chicago), Independent research worker, *Department of Physiology, University of Rochester, Rochester, N. Y.*

Strohecker, Henry Fred, A.B. (Mercer), Ph.D. (Chicago), Assistant Professor of Biology, *Biology Department, Kenyon College, Gambier, Ohio.*

Stultz, Walter Alva, B.A. (Acadia), Ph.D. (Yale), Associate Professor of Anatomy, *College of Medicine, University of Vermont, Burlington, Vt.*

Sumner, Ruth, B.A. (Colorado State College of Education), M.A., Ph.D. (Colorado), Assistant Professor of Physiology, *Colorado State College of Agricultural and Mechanical Arts, Fort Collins, Colo.*

Sweet, Helen E., B.A. (Pomona), M.A. (Claremont), Ph.D. (Chicago), Associate Professor of Biology, *Santa Barbara State College, Santa Barbara, Calif.*

Talbot, Mary, B.S. (Denison), M.A. (Ohio), Ph.D. (Chicago), Professor of Biology, *Department of Biology, Lindenwood College, St. Charles, Mo.*

Tartar, Vance, B.S., M.S. (Washington), Ph.D. (Yale), *Biologist, State Oyster Laboratory, Gig Harbor, Wash.*

Tasker, Roy C., A.B. (Hillsdale), A.M. (Michigan), Ph.D. (Cornell), Associate Professor of Zoology, *Bucknell University, Lewisburg, Pa.*

Taylor, Alfred, B.A. (Oregon), M.A., Ph.D. (Oregon State College), *Biochemical Institute, University of Texas, Austin, Texas.*

Te Winkel, Lois Evelyn, A.B. (Oberlin), A.M., Ph.D. (Columbia), Associate Professor of Zoology, *Department of Zoology, Smith College, Northampton, Mass.*

Thoennes, Gregory, A.B., M.S. (DePaul), Ph.D. (St. Louis), Assistant Professor of Biology, *St. Mary's College, Winona, Minn.*

Thomas, Thurlo Bates, S.B. (Wooster), M.A. (Oberlin), Ph.D. (Harvard), Instructor in Biology, *The Phillips Exeter Academy, Exeter, N. H.*

Thornton, Charles Stead, A.B. (Harvard), A.M., Ph.D. (Princeton), Assistant Professor of Biology, Chairman of Department, *Kenyon College, Gambier, Ohio.*

Tipton, Samuel Ridley, A.B. (Mercer), Ph.D. (Duke), Instructor in Physiology, *Department of Physiology, Ohio State University, Columbus, Ohio.*

Tittler, Irving Albert, B.S. (Bethany College), M.A., Ph.D. (Columbia), Instructor in Biology, *Department of Biology, Brooklyn College, Bedford Ave. and Ave. H., Brooklyn, N. Y.*

Tobin, Charles Emil, B.S. (Charleston), Ph.D. (Yale), Assistant Professor of Anatomy, *University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

Todd, Arlie C., B.A. (Kalamazoo), M.S. (Kansas State), Ph.D. (Nebraska), Instructor in Zoology, *Department of Zoology, Louisiana State University, University Station, Baton Rouge, La.*

Todd, Robert Emerson, Jr., B.S. (Bowdoin), M.A., Ph.D. (Harvard), Instructor in Zoology, Colgate University, *Box 195, Hamilton, N. Y.*

Truitt, R. V. T., B.S., M.S. (Maryland), Ph.D. (American), Director, Maryland Department of Research and Education; Director, Chesapeake Biological Laboratory, *Solomons Island, Md.*

Uhrich, Jacob, A.B. (Doane), M.A. (Nebraska), Ph.D. (Chicago), Assistant Professor of Biology, *Kansas State Teachers' College, Pittsburg, Kan.*

Van Horn, Willis M., B.A. (Milton), M.A., Ph.D. (Wisconsin), Assistant Professor of Zoology, *Lawrence College, Appleton, Wis.*

Venard, Carl Ernest, B.A., M.S. (Ohio), Ph.D. (New York), Assistant Professor of Zoology and Entomology, *Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio.*

Vogel, Howard H., Jr., A.B. (Bowdoin), M.A., Ph.D. (Harvard), Associate Professor of Zoology, *Wabash College, Crawfordsville, Ind.*

Waggener, Roy Alfred, B.A. (LaGrange), M.A. (Brown), Ph.D. (Cornell), Professor of Zoology, Chairman of the Department of Zoology, *Carleton College, Northfield, Minn.*

Walker, Paul Andrew, A.B. (Bowdoin), Ph.D. (Harvard), Associate Professor of Biology, *Randolph Macon Woman's College, Lynchburg, Va.*

Walker, Roland, A.B., M.A. (Oberlin), Ph.D. (Yale), Instructor in Biology, *Department of Biology, Rensselaer Polytechnic Institute, Troy, N. Y.* (On leave for military service, '42, U. S. A.)

Waterman, Talbot Howe, A.B., M.A., Ph.D. (Harvard), On leave Society of Fellows, *Biological Laboratories, Harvard University, Cambridge, Mass.*

Watterson, Ray Leighton, B.A. (Coe College), Ph.D. (Rochester), Assistant Professor of Zoology, *Department of Zoology, University of California, Berkeley, Calif.*

Weatherby, Jesse Howell, B.S. (Mississippi A. and M.), M.A., Ph.D. (Johns Hopkins), Research Associate, *Department of Pharmacology, Medical College of Virginia, Richmond, Va.*

Wells, Nelson A., B.S., Ph.D. (California), Instructor in Biology, *San Francisco Junior College, San Francisco, Calif.*

Welty, (Joel) Carl, A.B. (Earlham), A.M. (Haverford), Ph.D. (Chicago), Professor of Zoology and Head of the Department of Biology, Beloit College, *Route 1, Beloit, Wis.*

Whittinghill, Maurice, A.B., (Dartmouth), Ph.D. (Michigan), Associate Professor of Zoology, *Department of Zoology, University of North Carolina, Chapel Hill, N. C.*

Wilbur, Charles Grady, B.Sc. (Marquette), M.A., Ph.D. (Johns Hopkins), Instructor in Biology, St. Louis University, *1710 W. Highland Ave., Milwaukee, Wis.*

Wilder, Janet, B.A., M.A. (Mount Holyoke), Ph.D. (Chicago), Instructor in Zoology, *Mount Holyoke College, South Hadley, Mass.*

WILDER, MAGEL CRAIG, A.B., A.M. (Brown), Ph.D. (Cornell), Assistant Professor of Biology, Pembroke College, Brown University, *Olneyville Station, R.F.D. No. 2, Providence, R. I.*

WILHELMI, RAYMOND WILLIAM, A.B. (Nebraska Wesleyan), Ph.D. (New York), Assistant Professor of Zoology, *Department of Zoology, University of Missouri, Columbia, Mo.*

WILSON, JOHN WOODROW, B.S., Ph.D. (Duke), Instructor in Zoology, *Duke University, Durham, N. C.*

WILSON, LOUISE PALMER, A.B. (Southwestern), M.S., Ph.D. (Pennsylvania), Assistant Professor, *Department of Zoology and Physiology, Wellesley College, Wellesley, Mass.*

WIMSATT, WILLIAM ABELL, A.B., Ph.D. (Cornell), Assistant in Anatomy, *Department of Anatomy, Harvard Medical School, Boston, Mass.*

WINSOR, CHARLES P., A.B., B.S., Ph.D. (Harvard), *Statistician, Frankford Arsenal, 20 Nassau St., Princeton, N. J.*

WOLF, E(MIL) ALFRED, Ph.D. (Breslau), Associate Professor of Biology, *University of Pittsburgh, Pittsburgh, Pa.*

WOLF, LEONARD NICHOLAS, B.S. (Saint Vincent College), M.S., Ph.D. (Pittsburgh), Professor of Biology, *University of Scranton, Scranton, Pa.*

WOLF, OPAL MARIE, A.B. (Southwestern), A.M., Ph.D. (Wisconsin), formerly Associate Professor of Biology, *Department of Biology, Goucher College, Baltimore, Md.*

WOLFSON, CHARLES, A.B., Ph.D. (Kansas), Instructor in Anatomy, *University of Kansas, Lawrence, Kan.*

WOODARD, THOMAS MARION, A.B., A.M. (Vanderbilt), Ph.D. (Princeton), Assistant Professor of Biology, *Vanderbilt University, Nashville, Tenn.*

WOLTERINK, LESTER FLOYD, A.B. (Hope College), M.A., Ph.D. (Minnesota), Instructor in Physiology and Pharmacology, *Department of Physiology and Pharmacology, Michigan State College, East Lansing, Mich.*

WRIGHT, PHILIP LINCOLN, B.S., M.S. (New Hampshire), Ph.D. (Wisconsin), Assistant Professor of Zoology, *Department of Zoology, Montana State University, Missoula, Mont.*

WULFF, VERNER JOHN, A.B. (Wayne), M.A. (Northwestern), Ph.D. (Iowa), Research Assistant in Zoology, *Department of Zoology, State University of Iowa, Iowa City, Iowa.* (On leave for military service, '42. Pvt., U. S. A. Air Force).

YANCEY, PATRICK H., Ph.D. (St. Louis), Professor of Biology, *Spring Hill College, Mobile, Ala.*

YEAKEL, ELEANOR HUGINS, A.B., M.A., Ph.D. (Bryn Mawr), Fellow in Biology, *The Wistar Institute of Anatomy and Biology, Philadelphia, Pa.*

YEATTER, R(ALPH) E(MERSON), B.S. (Michigan State), M.S., Ph.D. (Michigan), Game Specialist, Illinois Natural History Survey, *226 Natural Resources Building, Urbana, Ill.*

YOUNG, DIXIE, A.B., A.M. (Oklahoma), Ph.D. (Yale), Associate Professor of Zoology, *University of Oklahoma, Norman, Okla.*

ZALESKY, MOSES, A.B., Ph.D. (Chicago), Educational Director, B'nai Zion Schools, Chicago, *Hull Zoological Laboratory, The University of Chicago, Chicago, Ill.*

ZANGERL, RAINER, Ph.D. (Zurich), Instructor in Biology, *Biology Department, University of Detroit, Detroit, Mich.*

ZWEIFACH, BENJAMIN WILLIAM, B.S. (College of the City of New York), M.S., Ph.D. (New York), Research Associate in Biology, New York University, *26 Washington Place, New York, N. Y.*

ZWILLING, EDGAR, B.S. (Brooklyn College), M.A., Ph.D. (Columbia), Assistant Instructor, Storrs Agricultural Experimental Station, *University of Connecticut, Storrs, Conn.* (On leave for military service, '43, *Lt. U. S. A. Air Force, Aviation Physiologist, Reno Army Air Base, Reno, Nev.)*

Totals

Life members	2
Active members	752
Associate members	308
Grand total	1062

OVARIAN HYPERTROPHY IN RATS UNITED IN PARABIOSIS WITH LITTERMATES PREVIOUSLY TREATED WITH ANTIGONADOTROPIC SERA [1]

HERBERT S. KUPPERMAN,[2] ROLAND K. MEYER
AND JOHN C. FINERTY [3]
Department of Zoology, University of Wisconsin, Madison

In earlier experiments we have shown that injections of antigonadotropic serum into female rats produce not only atrophy of the gonads but also changes in the cytology and physiology of the pituitary glands similar to those seen subsequent to castration (Finerty, Kupperman and Meyer, '40; Kupperman, Meyer and Finerty, '42). The cytological changes in the pituitary gland consist mainly of an increase in size and number of the basophilic cells accompanied by a decrease in number of the chromophobes. Associated with the induced basophilism of the pituitary gland, the gonadotropic content of the hypophysis after antihormone treatment approximated that of the glands of animals castrated for a period of time equal to that during which the antihormone treatment was given (Meyer, Kupperman and Finerty, '42). An increased secretory activity of pituitary gonadotropic hormone by the antihormone-treated animals was also indicated by the precocious gonadal development occurring in immature female rats following cessation of antihormone injections (Meyer and Kupperman, '39; Finerty, Kupperman and Meyer, '40; Kupperman, Meyer and Finerty, '42).

In order to demonstrate further the castration-like effect of antigonadotropic sera upon the pituitary gonadotropic secretion, the technique of parabiosis has been employed. Kallas ('29) first utilized the parabiosis technic to demonstrate the effect of castration upon the hypophyseal gonadotropic secretion. He noted that the gonadotropic secretion from the castrated rat's pituitary is increased greatly as evidenced by the precocious gonadal development in normal females placed in parabiosis with castrated males. In the experiments to be

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[2] Present address: Department of Experimental Medicine, University of Georgia School of Medicine, Augusta, Georgia.

[3] Present address: Department of Anatomy, University of Michigan School of Medicine, Ann Arbor, Michigan.

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described the hypersecretion of the gonadotropic hormone of the pituitary glands of antihormone-treated rats was demonstrated by observing the gonadal hypertrophy recorded in female rats paired to littermate male or female rats previously treated with antihormone.

PROCEDURE

Male and female rats received antigonadotropic serum for only 10 days prior to being placed in parabiosis with intact littermate females. The antigonadotropic serum was prepared by centrifugation of blood obtained by cardiac puncture of rabbits that had received repeated injections of an unfractionated supercentrifuged aqueous extract of sheep's pituitary glands prepared according to the method of McShan and Meyer ('40). The antiserum was not specific inasmuch as it inhibited the gonad-stimulating action of extracts of sheep's pituitary glands, human pregnancy urine, pregnant mare's serum, and suspension of rats' and human pituitary glands. The serum was also effective in preventing the action of endogenous gonadotropic secretion of rats' hypophyses (Kupperman, Meyer and Hertz, '39). Ten male and nine female rats were treated from the seventeenth to the twenty-seventh day of life with 0.5 cc. of antigonadotropic serum per day, or a total dose of 5 cc. of serum. In addition fifteen male and five female rats were similarly treated from the twenty-first to the thirty-first day of life. At 31 days of age — 4 days after the injections were discontinued for the rats treated from the seventeenth to the twenty-seventh day of life and immediately after cessation of treatment for the animals injected from the twenty-first to the thirty-first day of life — each animal that had received the antihormone was parabiotically united with an intact littermate female in such a manner that the injected animal was the "right" partner and the intact littermate female the "left" partner. The operative technique was similar to that described by Bunster and Meyer ('33) as modified by Meyer and Hertz ('37). No other treatment was given these animals and neither animal was castrated. The rats were autopsied on the forty-first day of life, after having been in the parabiotic union for 10 days.

Controls for the pairs described above were attained by injecting normal rabbit serum into male and female rats and uniting them parabiotically with intact littermate females. One-half cubic centimeter of normal rabbit serum per day, or a total dose of 5 cc. of serum, was administered to eight males and four female rats from the seventeenth to the twenty-seventh day of life. These and eight uninjected intact males and seven untreated females, were each joined parabiotically at

31 days of age to littermate females. The latter group of intact, uninjected pairs served as control animals for the pairs in which one member had been treated with sheep antigonadotropic or normal rabbit serum. The animals that had received the normal serum were always the "right" partners. The control pairs were autopsied at 41 days of age after being in parabiosis for 10 days. At autopsy the ovaries and testes, seminal vesicles and prostate glands were dissected free and weighed to the nearest milligram.

In addition to the control pairs single animals were also used for control data. One group of eighteen males and one of eighteen females were killed on the twenty-seventh day of life. One-third of these animals received 0.5 cc. of antigonadotropic serum per day between the seventeenth to the twenty-seventh day of life, or a total dose of 5.0 cc. Another third (littermates) were castrated on the seventeenth day of life while the remaining animals, also littermates, served as intact controls. The antihormone-treated animals were killed on the twenty-seventh day of life to determine the effect of the serum on the gonads of animals similarly treated from the seventeenth to the twenty-seventh day of life with antihormone, but which had been placed in parabiosis on the thirty-first day of life with an intact female rat. The weights of the uteri, seminal vesicles and prostates of the littermate rats castrated on the seventeenth day of life and killed on the twenty-seventh day show that the effects produced by antihormone injections are similar to those found after gonadectomy when the period subsequent to castration equals the period of antihormone administration. The normal intact rats, which were littermates of the antihormone-treated and castrated animals provided data for the intact animals 27 days of age. In addition to the single rats killed on the twenty-seventh day of life, eight male and seven female, untreated, rats were killed on the forty-first day of life to serve as intact controls for the parabiotic animals autopsied at the same age.

The pituitary glands of the individual castrated, antihormone-injected and normal animals killed on the twenty-seventh day of life and of some of the antihormone-treated partners of the parabiotic rats autopsied on the forty-first day of life were fixed in Bouin's and prepared for microscopic study. The glands were sectioned at 6 microns and stained with a modification of Mallory's trichrome stain (Rasmussen, '30). Three horizontal sections from equidistant levels in the glands were studied in each animal. In each of these sections all the cells in every tenth field were differentially counted. The percentages of the three cell types in the pituitary glands were calculated for three to four animals in each group for both the male and the female animals.

RESULTS AND DISCUSSION

The data given in table 1 show that ovarian hypertrophy occurred in littermate females parabiotically united to male or female rats that had been treated with antigonadotropic serum prior to the parabiotic union. However, the "left" females of pairs in which the "right" partners had been injected with antigonadotropic serum from the twenty-first to the thirty-first day of life and then united to untreated littermate females on the thirty-first day show less ovarian hypertrophy than those pairs in which the "right" animals had been injected from the seventeenth to the twenty-seventh day of life, and parabiotically united four days later on the thirty-first day of life. The absence of pronounced ovarian stimulation in animals paired the day after the last injection of antihormone may be explained on the basis that sufficient time had not elapsed before parabiosis for the destruction or elimination of the antihormone in the blood stream of the injected animal and/or the animals were killed before the gonadotropic secretion of the pituitary gland of the animals treated with antihormone had produced its maximum effect in the untreated female partners.

TABLE 1

Ovarian hypertrophy in parabiotic rats, one partner of which had been treated with antigonadotropic serum prior to parabiosis.

NO. OF PAIRS	FEMALE-FEMALE PAIRS[1] Average ovarian weight		TREATMENT PRIOR TO PARABIOSIS	NO. OF PAIRS	FEMALE-MALE PAIRS[1] Average organ weight			
	Left female	Right female			Left female	Right male		
					Ovary	Testis	Seminal vesicle	Prostate
	(mg.)	(mg.)			(mg.)	(mg.)	(mg.)	(mg.)
9	64	41	Antigonad. serum 0.5 cc./day 17–27th day	10	89	780	34	102
5	29	22	Antigonad. serum 0.5 cc./day 21–31st day	15	38	508	15	35
4	14	13	Normal rabbit serum 0.5 cc./day 17–27th day	8	15	822	13	49
7	15	18	No treatment	8	19	1021	14	48

[1] All animals killed on 41st day of life after 10 days of parabiotic union.

Ovarian stimulation was evident in both the "left" and "right" females of the pairs, the "right" females of which had been treated from the seventeenth to the twenty-seventh day of life and then parabiotically united on the thirty-first day with an untreated littermate female. Gonadal hypertrophy, however, was observed only in the untreated females in the female-male pairs. The testes of the antihormone-treated partners in the female-male pairs were of the same weight as those of the control pairs. The seminal vesicles and prostate glands, on the other hand, were definitely stimulated. The explanation of this apparent inconsistency, whereby precocious gonadal hypertrophy occurs in female rats treated with antihormone before parabiosis, but not in similarly treated males is obvious if we consider the data of the rats killed at 27 days of age, after 10 days of treatment with antigonadotropic serum (table 2). The effect of 10 days' treatment with antigonadotropic serum on the seminal vesicles and prostates is similar to that observed after 10 days of castration. The relative atrophy of the male gonads and accessories after a 10-day period of antihormone treatment was greater than that in the female gonads. The testes at the time of cessation of antihormone treatment were extremely atrophic and their weight was one-fifth that of normal control animals. Hence upon cessation of the antigonadotropic injections it was first necessary for the pituitary gland to restore the testes to normal weight before additional hypertrophy could occur. At the time of autopsy the testes had developed from their original atrophic state to one where their weights were not significantly less than those of the controls. In the female-female pairs, however, the ovaries of the rats that had been treated with antihormone were only one-half as large as those of normal controls at the time of cessation of injections, 4 days before parabiosis

TABLE 2

Effect of antigonadotropic serum and castration on the reproductive tract of 27-day-old rats.

TREATMENT [1]	FEMALE		MALE		
	Ovary	Uterus	Testes	Seminal vesicle	Prostate
	(mg.)	*(mg.)*	*(mg.)*	*(mg.)*	*(mg.)*
Normal	14.5	26	3 ·7	6.4	42
Injected 17th–27th day [2]	6.8	17.6	77	3.8	14.6
Castrated 17th day	..	18.0	...	4.2	15.0

[1] Six animals in a group.

[2] Injected with 0.5 cc. of sheep antigonadotropic rabbit serum per day for 10 days.

(table 2). Hence, after cessation of antihormone treatment, the gonadotropic hypersecretion of the pituitary gland was more effective in increasing gonadal weight in the female than the male rats, since the ovaries of the animals treated with antihormone had not undergone as extensive atrophy as the testes of similarly treated males. Nevertheless, precocious gonadal stimulation, without apparent hypertrophy, did occur in the antihormone-treated male rats since 14 days after cessation of treatment the testes had secreted sufficient male hormone to cause the seminal vesicles and prostates of these animals to grow to twice the size of those in the control animals (table 1).

In the female-female parabionts, in which one partner had received antigonadotropic serum before parabiosis, gonadal hypertrophy was observed in both members of the pairs. The final ovarian weight of the treated members, however, was not equal to that attained by the untreated parabiotic female rats. This may be explained on the basis that the gonadotropic secretion of the antihormone-treated animals was released into the blood system of both animals during parabiosis. As a result, the hypersecretion of the hypophyseal gonadotropic hormone by the animals treated with antigonadotropic serum greatly increased the weight of the gonads of the untreated females. It is probable that the gonadotropic hormone was equally as effective on the subnormal gonads of the antihormone-treated animals, but the final weight of the ovaries was not as great because of the intital atrophic condition of the ovaries.

The uninjected control pairs and the pairs in which the "right" partner had been previously treated with normal rabbit serum from the seventeenth to the twenty-seventh day of life, did not show ovarian hypertrophy in the "left" untreated females beyond that observed in the single intact animals killed at the same age. These data indicate that the ovarian hypertrophy occurring in rats parabiotically united to littermates which had received antigonadotropic rabbit serum cannot be explained on the basis of a non-specific action of the serum (table 1). The possibility of a gonad-stimulating factor being present in the serum may also be eliminated since the gonads of the control animals killed on the twenty-seventh day of life immediately after cessation of antihormone injections were atrophic (table 2).

The effects of the antigonadotropic serum and castration upon the percentage of cell types in the pituitary gland are given in table 3. The basophilism induced in the pars distalis by the antihormone treatment resembles that of the castrated animal as determined by the quantitative and qualitive study. Extreme basophilism was present in both types of glands when compared to the pars distalis of the hypophysis of the normal littermate animal. In the hypophyses of the male and female antihormone-injected and castrated animals the percentage of chromophobes was lower than that in the glands of normal animals and this decrease corresponded to the increase in basophiles. The percentage of acidophiles remained constant throughout. On the forty-first day of life the anterior pituitaries of the "right" partners of the pairs treated with antihormone from the seventeenth to the twenty-seventh day of life were comparable to the glands of normal animals indicating that the basophilism present on the twenty-seventh day of life had subsided 14 days later.

TABLE 3

Effect of antigonadotropic serum and castration on the percentage of cell types in the hypophyses of 27-day-old rats.

TREATMENT	NO. OF RATS	SEX	% OF ACIDOPHILES	% OF BASOPHILES	% OF CHROMOPHOBES	NO. OF CELLS [2]
Normal	4	Male	19.2	8.9	71.9	2095
	4	Female	17.9	6.1	75.9	3030
Injected 17–27th day [1]	3	Male	17.5	25.8	56.8	2662
	3	Female	18.0	22.3	59.6	2620
Castrated 17th day	3	Male	18.7	24.2	57.0	2490
	3	Female	17.7	27.2	55.2	2558

[1] Injected with 0.5 cc. of sheep antigonadotropic rabbit serum per day for 10 days.

[2] Average number of cells counted per gland.

The explanation of the mechanism of the gonad-stimulating effect of antigonadotropic serum is essentially the same as that reported for the single rats (Meyer and Kupperman, '39; Kupperman, Meyer and Finerty, '42). Treatment of the "right" partner with antigonadotropic serum results in a condition in the pituitary gland and accessory reproductive organs similar to that seen following castration (table 2). The explanation for this is based in part on the fact that the serum somehow inactivates the endogenous gonadotropic secretion produced by the pituitary gland of the injected animal. As a result the gonads receive little, if any, stimulation and consequently, produce little, if any, gonadal hormone. The absence of the sex hormone causes castration changes to develop in the anterior pituitary and subsequently there is an increase in gonadotropic hormone in the gland and in the blood (Kallas, '29; Meyer and Hertz, '37). Upon cessation of injections the increased activity of the pituitary gonadotropic hormone, being no longer neutralized by further antigonadotropic treatment, produces gonadal stimulation or hypertrophy in both parabionts. Associated with the gonadal stimulation, there is an increased secretion of gonadal hormones which, in addition to stimulating the accessory reproductive organs, are free to act on the hypophysis. Consequently, the castration changes present in the pituitary glands immediately after antihormone administration soon subside under the influence of the gonadal hormones and a normal histological picture prevails.

SUMMARY

1. A marked degree of ovarian hypertrophy was observed in immature female rats parabiotically united to littermates previously treated with antigonadotropic serum.

2. The antihormone-treated animals were injected for 10 days with sheep antigonadotropic rabbit serum prior to parabiosis. One or 4 days after cessation of antiserum treatment the injected rats were placed in parabiosis with immature female littermates.

3. The ovarian hypertrophy observed in the immature female rats after 10 days of parabiotic union with the animals treated with antigonadotropic serum indicated the increased level of secretion of the gonadotropic hormone from the hypophysis of the antihormone-treated animal.

4. In addition to the castration-like effect of antigonadotropic serum upon the secretion of the gonadotropic hormone from the hypophysis, the histological and gross changes produced in the pituitary gland and reproductive tract by the antiserum simulate those seen after removal of the gonads.

5. The results of quantitative differential cell counts of the three cell types in the pars distalis of the hypophyses of the antihormone-treated, gonadectomized and normal control animals showed that there was a marked increase in basophiles in the glands of the castrated and antihormone-treated animals. The degree of basophilism found in the hypophyses of the animals treated for 10 days with antigonadotropic sera was the same as that observed in animals castrated for a corresponding period of time.

6. Control pairs were attained by treating immature rats with normal rabbit serum before parabiosis. In these pairs there was no evidence of increased secretion of gonadotropic hormone from the pituitary glands of animals so treated.

7. The mechanism whereby ovarian hypertrophy occurs in immature rats parabiotically united to littermates treated with antihormone is discussed.

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A NOTE ON THE ARGENTAFFIN CELLS OF THE GASTRIC MUCOSA OF THE RAT

ALDEN B. DAWSON
The Biological Laboratories, Harvard University, Cambridge, Massachusetts

ONE PLATE (THREE FIGURES)

This record of the relatively high incidence of argentaffin cells in the gastric mucosa of the rat is a by-product of a study of the cytogenesis of the parietal cells. A need was felt for a more reliable method of demonstrating the early appearance of the intracellular canaliculi than silver impregnation by the rapid method of Golgi. A silver method seemed indicated since selective staining methods did not yield sufficiently complete or contrasting pictures of the canalicular system. Accordingly a survey was begun of the more modern silver methods, especially of those that permitted impregnation of the tissues on the slide, following embedding and cutting in paraffin.

We were fortunate in selecting early Bodian's ('36, '37) protargol method; not however for its value in demonstrating canaliculi of the parietal cells. This it utterly failed to do, and a first inspection of the slides suggested that instead the entire bodies of the parietal cells had been impregnated. A closer study, however, showed that the parietal cells had not reacted with the silver but that numerous granular cells, very like them in appearance, had been blackened. These silver-reducing cells were more "parietal" to the gastric tubule than the parietal cells themselves. They were provisionally interpreted as argentaffin or enterochromaffin cells although it was felt at the time that the literature on the subject reported such cells as absent from the rat's stomach or occurring in relatively few numbers. An extension of the Bodian technique to the duodenum showed that the method also blackened typical argentaffin cells of the intestine and that in this region of the small intestine they were present in the usual numbers and positions as they are when demonstrated by the classical method of Masson-Hamperl.

A survey of the literature (necessarily incomplete since 1939) failed to uncover any detailed description or illustration of argentaffin cells in the rat stomach. In most instances the chief emphasis was placed on the occurrence of these cells in the small intestine, especially the duodenum (Tang, '22; Kull, '25; Cordier, '26) with passing or indirect reference to the stomach, the implication being that argentaffin cells were not present in any great numbers in the gastric mucosa. The most direct statement is made by Jacobson ('39) who states that in the rat argentaffin cells are completely or almost completely absent from the stomach, including the pyloric region. In the more recent experimental studies of the argentaffin cells in which the rat has been used, the intestine rather than the stomach has served as an index of the changes effected (Klemm, '37; Hallier, '37; Vetter, '37; Münch, '39).

No attempt will be made to review the various problems associated with the argentaffin cells: their proper identification, their origin and manner of replacement, their occurrence in the several classes of vertebrates, their distribution in these animals, especially in the several regions of the digestive tract, the chemical nature of their granulation or their function. Good summaries are given by Hamperl ('25), Clara ('33) and Macklin and Macklin ('32) and the more recent papers have added little to our fundamental knowledge of the cells. Additional hypotheses have been formulated regarding their function, a recent one being that they are the possible source of the anti-anemic factor.

Since these argentaffin cells have apparently not been previously demonstrated in large numbers in the rat stomach, the problem of their identity and homology must receive consideration. The Bodian method is certainly not specific for these cells alone, since it also blackens the medullary cells of the adrenal, the alpha cells (?) of the pancreatic islands and certain cells of the anterior pituitary gland (Dawson and Barnett, '44). However, other silver methods also show similar capacities to impregnate other granulated cells (Clara, '33). This author points out if any of the impregnation methods are to be of value they must first of all act uniformly and consistently and that secondly the fewer types of cells demonstrated the greater the value of the method. If only one cell type reacted then a method would possess great electivity and could be regarded as specific for a single type of cell, but this is hardly realized in any method of silver impregnation. The Bodian method, however, is consistently uniform in the impregnation of these cells of the stomach and intestine and reacts with no other cells of the wall of the digestive tract.

The large number of cells demonstrated in the rat's stomach by the Bodian technique, in contrast with the few recorded after other silver impregnations such as Masson-Hamperl, may be due to the more complete impregnation of these elements by the Bodian method. In studies of the intestine, many authors, most recently Gillman ('42), have pointed out that many of the basal granular cells, demonstrable by other selective stains, are either incompletely impregnated or not impregnated at all by the silver methods employed. They attribute these variations in the reaction with silver to the varying degrees of ripeness of the granules.

The tissues were fixed in one of the fluids recommended by Bodian ('37), formalin, 5 cc.; acetic acid, glacial, 5 cc. and 80% alcohol, 90 cc., for 48 hours and cleared for embedding in cedar oil. The exposure to protargol (24 hours) and subsequent reduction were repeated once, since a single treatment did not give a sufficiently intense contrast. Usually the toning with gold chloride was omitted since cell detail was sufficiently clear and the blackened cells on a golden-yellow background were very conspicuous. Toning reduces this contrast although it improves the general histological picture. Clearing the block of tissue with toluol or xylol and long treatments of the sections on the slide with these reagents were avoided since they appeared to reduce the intensity of the silver reaction. Preparations were also stained with Heidenhain's hematoxylin and Heidenhain's azan method, either with or without previous impregnation with silver. The same stains were also applied after fixation in Regaud's fluid. No impregnation was obtained after Regaud's fluid.

The fundic and pyloric regions of the stomach were most carefully examined. The cardiac region in the rat, as in many rodents, is small and poorly defined owing to the great encroachment of the esophageal type of epithelium into the gastric cavity (Kammeraad, '42). In the tubules of the fundus the chief cells are relatively very abundant in the deeper-lying portions and the less numerous parietal cells are crowded away from the glandular lumen and appear as bulges on the tubule walls. In the mid-portion, the parietal cells are relatively more numerous and approach nearer to the lumen, while in the upper third the chief cells are almost entirely absent and the parietal cells lie directly on the lumen. The shape of the parietal cells varies with their location. Deep in the gland they are somewhat crescentic or low triangular in form, with the major surface applied to the basement membrane and the angular tip wedged between the bases of adjacent chief cells. As the parietal cells approach nearer the lumen in the middle third of the tubule they become taller and are fully inserted between the chief cells while toward the foveolae they appear almost rectangular with a wide surface bordering on the lumen.

In following the changing shape of the parietal cells one gains the impression of great crowding in the deep portion of the tubules with decreasing congestion as the surface of the mucosa is approached. This impression is heightened when attention is directed toward the argentaffin cells. First of all, it is seen that the distribution of argentaffin cells parallels remarkably that of the chief cells, being restricted chiefly to the deeper one-half of the mucosa although scattered cells may be found all the way to the bases of the foveolae (fig. 1). Furthermore the deep-lying argentaffin cells occupy an extremely peripheral position on the tubule wall and appear to be greatly compressed between the epithelium of the gastric gland and the connective tissue of the tunica propria (fig. 2). They accordingly can hardly be described as intraepithelial, but extraepithelial or interstitial seems too strong a term. I prefer to refer to them as periglandular. In tangential sections of the tubule they frequently appear as irregular branched bodies resembling fibroblasts in outline (fig. 3). However in the more superficial portions of the mucosa, where the glandular epithelium is predominantly made up of parietal cells, the more scattered argentaffin cells become more intimately associated with the tubule wall and gradually become wedged deeper between the parietal cells — even occupying a true intraepithelial position.

As the pyloric region is approached both the parietal and chief cells become gradually reduced until the typical pyloric glands are encountered. Here the glands are not closely packed and the loose connective tissue between them is relatively abundant. The number of argentaffin cells is greatly reduced and practically all occupy an intraepithelial position, frequently extending between the pyloric cells, to border on the glandular lumen. They are scattered irregularly through the epithelium but show a slight tendency to be aggregated deep in the mucosa as in the fundic region. The density of their distribution in the pyloric region is very comparable to that of the superficial half of the fundic mucosa (fig. 1). However, here as in all other regions of the stomach, the granules are found all through the cytoplasm and are not confined to the basal region of the cells. The term ''basal granular cells'', so frequently used as a synonym for chromaffin and argentaffin cells, is not appropriate for the cells of the rat's stomach.

Ordinarily the argentaffin cells are mononucleate but a few binucleate cells are also encountered. However, in a narrow prepyloric zone in which parietal and chief cells are relatively few, the argentaffin cells are frequently aggregated in relatively compact masses in which as many as ten nuclei may be counted in a single section. The nuclei are closely grouped and no evidences of cell membranes could be distinguished.

As Gillman ('42) has indicated, the shape of the argentaffin cell depends on several factors, the more important of which are its location in the mucous membrane and the type of cell with which it is associated. We have already seen how this cell is crowded to the periphery in the deep portion of the fundic gland. Here the chief cells border immediately on the lumen and force the parietal cells peripherally and the argentaffin cells, in turn, seem to accommodate themselves to the residual space so as not to be forced from a contact association with the glandular epithelium. Moreover, this peripheral position of both parietal and argentaffin cells seems to be independent of the secretory state of the chief cell. Zymogen storage or depletion does not affect their position. However in the superficial half of the fundic mucosa the argentaffin cells occupy an intraepithelial position between the parietal cells, almost comparable to their location in the pyloric glands and in the duodenal mucosa.

Gillman suggests that the physical state of the argentaffin cell and the degree which it may be compressed by adjacent cells is directly related to the degree of its granulation. The more completely granulated a cell, the more it suffers compression by its neighbors. These correlations between granulation and ease of compression are based largely on conditions in the Brunner's glands where the argentaffin cells are often forced into a periglandular position as in the fundic tubules. The cause of the greater intracellular pressure in a cell devoid of granules, and its ability to resist distortion or even displacement by its neighbors is not clear. Similar evidence is not at hand in the rat, since all the cells appeared to contain many granules and no nongranular stages were recognized in either impregnated or non-impregnated preparations counterstained by iron hematoxylin or the ''azan'' triple stain. The degree and density of the granulation varied greatly from cell to cell, as well as the intensity of the blackening with silver. However, there did not appear to be any close correlation between density of granulation or intensity of blackening and the amount of compression exhibited by an individual cell.

The epithelial relations in the fundic mucosa are much more complex than they are in the intestinal mucosa or even in Brunner's glands. It has not been found possible to identify and count as many argentaffin cells in a selectively stained preparation as in an impregnated preparation and no clear evidences of cyclic activity have been found. Furthermore counterstaining of silvered preparations has not demonstrated any granular cells of this type beyond those already blackened by silver.

SUMMARY

A high incidence of argentaffin cells is reported for the gastric mucosa of the rat, in fact higher than that recorded or illustrated for any other mammal. The discrepancy between our observations and those of earlier workers would seem to be due to the completeness of the impregnation of these cells by the Bodian protargol technique. With other silver methods many authors describe the occurrence of many granular cells whose granules do not react with silver. This is frequently attributed to the level of differentiation attained by the granules.

In the fundic mucosa the argentaffin cells usually do not occupy an intraepithelial position, especially in the deeper portion of the fundic tubule where even the chief and parietal cells seem to compete for space. However, they should not be classified as extraepithelial or interstitial since their position appears to be the resultant of many factors and is not necessarily related to their place of origin. The strongest term admissable in this case is periglandular. In the pyloric glands the argentaffin cells are frequently typically intraepithelial.

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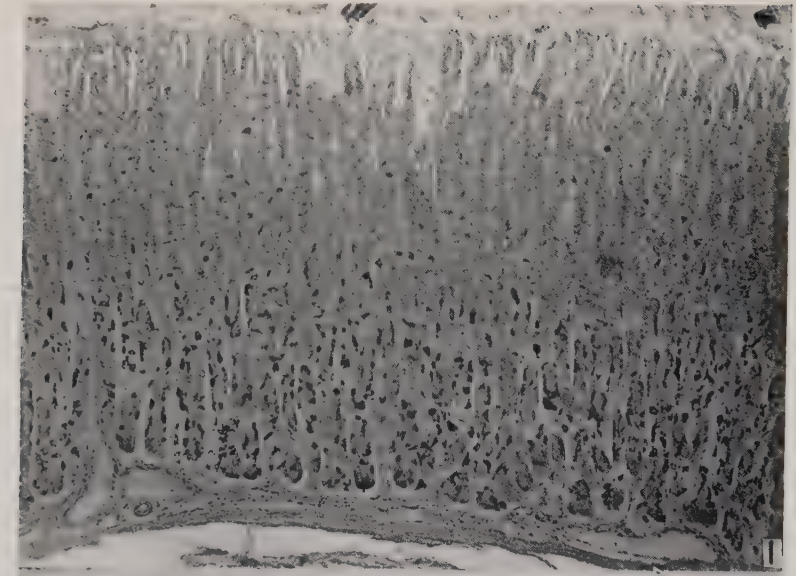
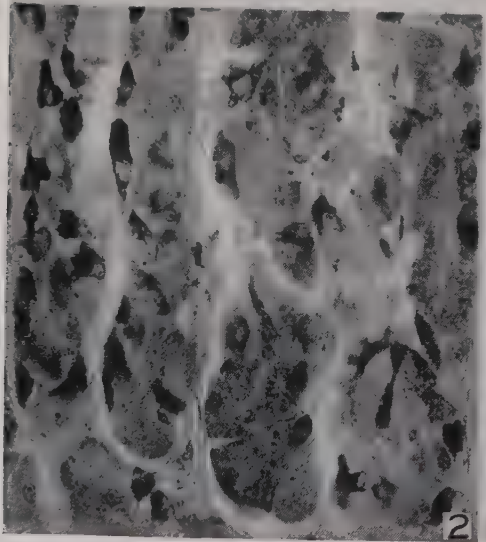
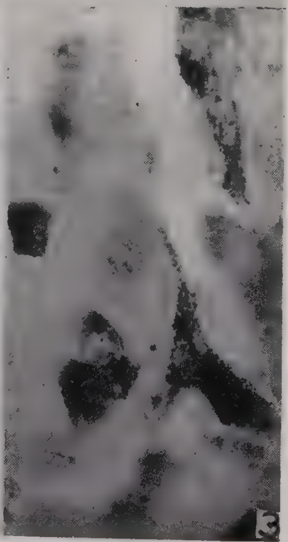






1 A vertical section through the fundic mucosa of the rat showing the number and distribution of the argentaffin cells. They are restricted chiefly to the deeper one-half of the mucosa but scattered cells occur all the way to the gastric foveolae. Argentaffin cells are rarely found in the epithelium of the foveolae. (Bodian impregnation, 15 μ thick, × 96).

2 A region from the inner half of the mucosa showing the relationship of the argentaffin cells to the fundic tubules. Many of the cells lie in an extreme peripheral position and present an appearance of being compressed by the gastric epithelium proper. (× 470).

3 Tangential section through a gastric tubule showing the irregular outlines of two argentaffin cells. The gastric epithelium proper is out of focus. The argentaffin cells appear to accommodate themselves to the residual space left between the chief and parietal cells and the connective tissue membrane of the tunica propria. (× 960).

THE RENAL FASCIA AND ITS RELATION TO THE TRANSVERSALIS FASCIA

CHARLES E. TOBIN
Department of Anatomy, The University of Rochester School of Medicine and Dentistry, Rochester, New York

TWELVE FIGURES

INTRODUCTION

Although many papers have been published on the structure of the renal fascia and its relations to the transversalis fascia and peritoneum previous to and since its description by Gerota (1895), there still exists a considerable amount of vagueness and misunderstanding in the description of the renal fascia given in many textbooks of anatomy and surgery. One of the causes of this confusion arises from describing the renal fascia as a continuation and splitting of the transversalis fascia at the lateral border of the kidneys, as given in some texts (Callander, '39). If this concept be true, then para-renal fat, which lies external to the renal fascia, would be exterior to the transversalis fascia where fat is not found normally. This premise also connotes that a fascial layer like the transversalis, which is parietal in most of its extent, becomes a visceral fascia in a limited area. The different embryological origins of the body wall and the kidneys would not suggest that they share a common fascial layer.

Although most of the texts agree as to the structure and continuation of the transversalis fascia on the ventral abdominal wall, diaphragm and into the pelvis, considerable disagreement is found in the descriptions of this fascia in the kidney region. For example, this fascia is described as: (1) continuous with the fascia of the quadratus lumborum and psoas muscles (Cunningham, '43); (2) lost in the fat which covers the posterior surface of the kidney (Gray, '42); (3) divided at the lateral margin of the quadratus lumborum, one lamina passing dorsal to this muscle to be attached to the lumbo-dorsal fascia; the other lamina extends over the ventral surface of the quadratus lumborum and becomes fused with the psoas fascia (Morris, '42); and (4) continuous with the strong aponeurosis formed by the fusion of the superficial and deep layer of the lumbo-dorsal fascia (Piersol, '30). The lack of a clear definition of the transversalis fascia, therefore, appears to be one of the main causes for vagueness as to the origin, nature and extent of the renal fascia.

Gerota (1895) described two layers of fascia covering the internal surface of the transversus abdominis muscle: (1) a strong, fascial membrane of connective tissue close to the muscle fibers and (2) a loose layer, partially adipose and partially lamellar, immediately external to the peritoneum (retro-peritoneal tissue) which gives rise to the renal fascia. The former is the fascia usually accepted as the true transversalis fascia; whereas the latter, depending on the amount of retro-peritoneal fat and connective tissue present, is sometimes referred to surgically and antomically as the transversalis fascia.

Furthermore, inconsistencies are also found in the literature regarding the connections of the anterior and posterior lamina of renal fascia of the opposite sides with each other, with the renal vessels, aorta, vena cava and vertebrae. In regard to the caudal continuation of the renal fascia, the descriptions are not clear as to its relationship to the ureter and spermatic (or ovarian) blood vessels; nor is it clear whether the adrenal is separated from the kidney by a fascial layer. Much of the confusion appears to be due to the different meanings applied to the term renal fascia, the retro-peritoneal connective tissue and fat.

The importance of the renal and transversalis fasciae in anatomy and surgery and the confused state of present knowledge and terminology, suggested a restudy of these problems as reported below.

MATERIAL ANND METHODS

A study was made of serial sections of three early embryos with crown-rump lengths of 19.5, 58 and 145 mm. Gross dissections were carried out on three premature fetuses, one new-born infant and ten adult cadavers. The fascial layers of the abdomen in the gross dissections were studied either by progressive dissection or by dissection of transverse sections made through the kidney region to permit display and study of these layers from both a cephalic and caudal approach. The material was kept moist while being dissected and stored in preserving solution to give maximum pliability to the fasciae. In a few specimens, the kidney with its intrinsic capsule was removed and the renal vessels and ureter cut at the renal pedicle, to provide a better study of the space formed by the renal fascia and its relations to the blood vessels, ureter and adrenal gland.

Premature and new-born specimens are ideal for such studies since the fascial layers are well formed and more uniform in structure than the various patterns found in the adult resulting from differences in body-type. The amount of peri- and para-renal fat is also small and the primitive peritoneal layers can be dissected and studied with greater ease than in the adult. However, since growth and mechanical factors as well as change in positions of the kidneys and adrenals from the fetal to the adult location influence the form of the renal fascia, the structure of the latter was compared with that from specimens of middle-aged male cadavers of varying obesity.

For the sake of uniformity in description, the fasciae discussed are defined as follows. (1) The transversalis fascia is a layer of dense, collagenous-elastic connective tissue which is immediately adjacent to the inner surface of the transversus abdominis muscle and its intrinsic fascia. It is continuous with the sub-diaphragmmatic fascia cephalad and the pelvic fascia caudad. In the kidney region it is ventral to, and separate from, the intrinsic fascia of the quadratus lumborum and psoas muscles; however there may be a fusion of the transversalis fascia with the intrinsic psoas fascia at the lateral border and anterior surface of this muscle. With care these layers can be separated in the mature cadaver and the attatchment of the transversalis fascia traced to the ventral surface of the bodies of the lumbar vertebrae. The separation of the transversalis fascia from the intrinsic fascia of the psoas muscle can be accomplished more readily in the fetus than in the adult. (2) The retro-peritoneal tissue is a layer of adipose and collagenous-elastic tissue situated between the peritoneum and transversalis fascia. The fat or connective tissue content of this layer varies with the obesity of the specimen. It is best developed on the dorso-lateral sides of the abdomen and, depending on the amount of fat present, may be split into many septae which contain the fat deposits. If well developed, it can be traced from the pelvis to the diaphragm. (3) The renal fascia is a layer of dense or intermediate collagenous-elastic tissue, arising from the retro-peritoneal tissue which splits into two prominent laminae at the lateral border of each kidney to form a sheath enclosing the kidney, peri-renal fat and adrenal in a common capsule. These laminae of renal fascia are distinct from the intrinsic capsules of the kidney and adrenal and the surrounding peri- and para-renal fat, and are attached to the renal vessels and ureter.

ANATOMICAL OBSERVATIONS

19.5-mm. (CRL) embryo. At the time that the definitive metanephric kidney is developing and the mesonephric kidney is degenerating (fig. 1), the renal and transversalis fasciae, the retro-peritoneal connective tissue and fat have not differentiated from the retro-peritoneal mesenchyme. Part of the small intestine is still outside of the abdominal cavity and the mesentery of the large intestine has not rotated and fused with the parietal peritoneum. Therefore the definitive kidneys are posterior to the primitive dorsal parietal peritoneum and are imbedded in a layer of mesenchyme. This mesenchymal bed about the kidneys and adrenals also contains the aorta, subcardinal veins, renal vessels and ureters. It is continuous laterally between the peritoneum and abdominal musculature and extends caudad into the pelvis and cephalad to the diaphragm.

Figs. 1–4 are photomicrographs of transverse sections through the abdomen of human embryos.

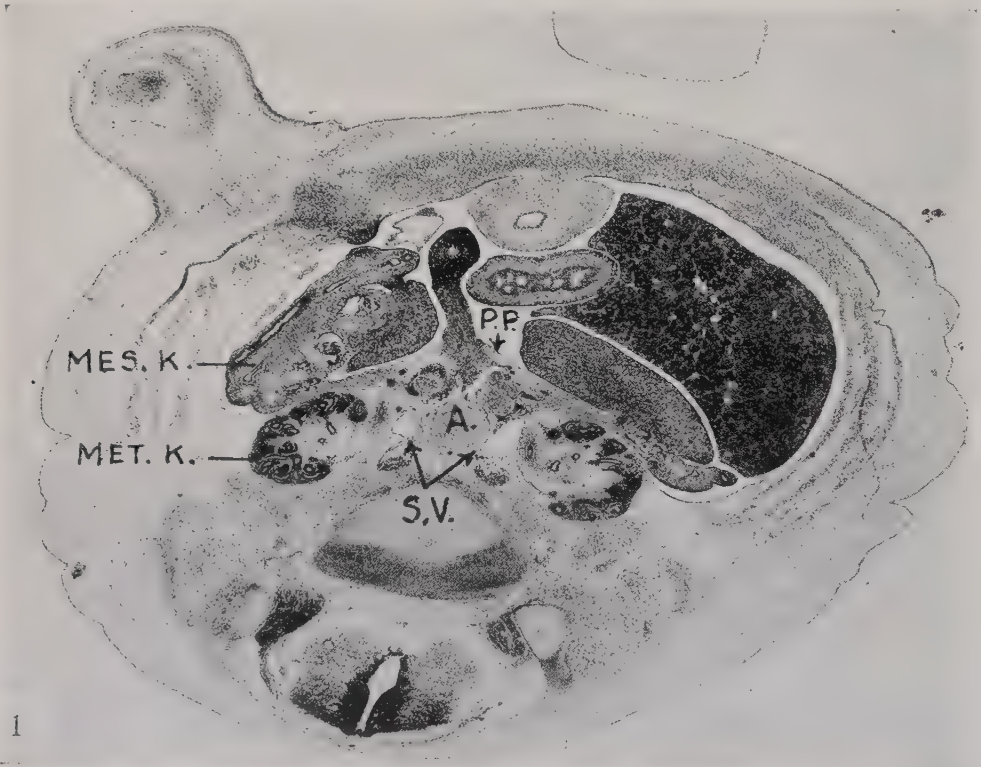


Fig. 1 19.5-mm. (CRL) embryo. The developing metanephric (MET. K.) and degenerating mesonephric (MES. K.) kidneys are shown in this section. The metanephric kidney, aorta (A.) and subcardinal veins (S. V.) are imbedded in a common layer of mesenchyme, covered ventrally by parietal peritoneum (P. P.). The mesenterial peritoneum of the colon has not rotated to fuse with the parietal peritoneum. × 25, H and E stain.

58-mm. (CRL) embryo. In this specimen the mesonephros has degenerated and the metanephric kidney is developed further than in the preceding specimen. The small intestine is within the abdominal cavity and the large intestine has rotated, but its mesentery has not fused with the parietal peritoneum at the final position. The ventral surfaces of the kidney and adrenal of each side are covered by both mesenchyme and parietal peritoneum. The mesenchyme has become more fibrous but the renal, transversalis and intrinsic muscular fasciae have not differentiated from the fibrous-mesenchymal bed which contains the kidneys, adrenals, aorta, vena cava, renal vessels and ureters (figs. 2 and 3).

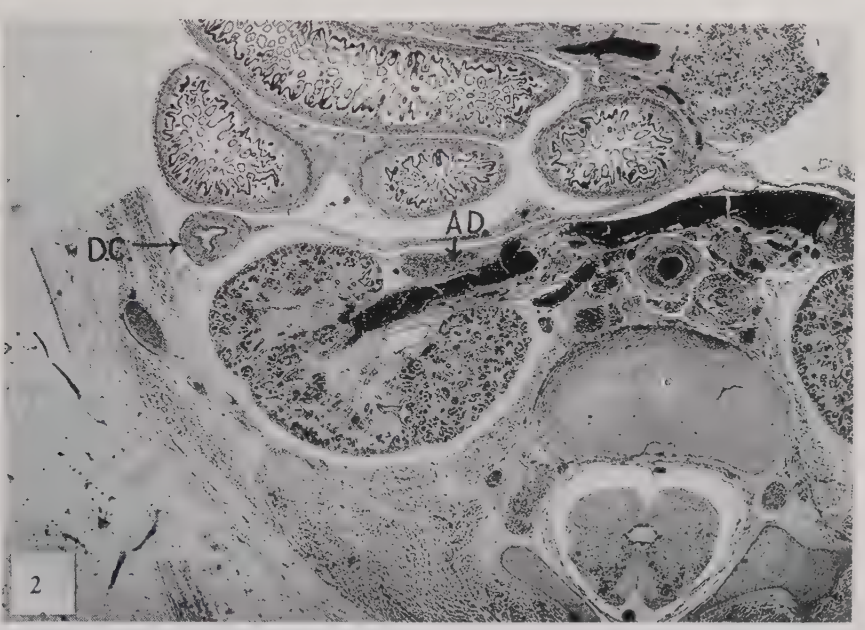


Fig. 2 58-mm. (CRL) embryo. The mesonephric kidney has degenerated and the metanephric kidney is further developed than in 19.5-mm. embryo. The mesenchyme enclosing the kidney, adrenal, aorta, vena cava, renal artery and vein in a common layer, has become fibrous, retro-peritoneal tissue. Note tissue separating adrenal gland (AD.) from kidney. The descending colon (D. C.) and its mesentery have rotated but have not fused with the parietal peritoneum. × 15, azocarmine — Mallory stain.

145-mm. (CRL) embryo. The renal fascia is differentiated in this specimen and is continuous laterally with the retro-peritoneal tissue. The aorta and vena cava are contained within this retro-peritoneal tissue, which is continuous across the vertebrae between the two kidneys. The mesentery of the ascending and descending colon, duodenum

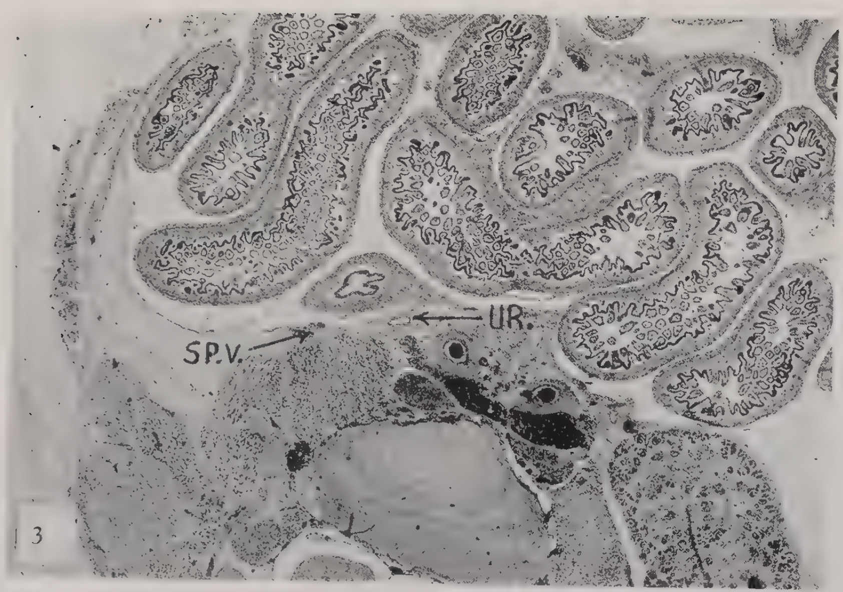


Fig. 3 More caudal section of embryo shown in figure 2. The ureter (UR.) and spermatic vessels (SP. V.) are imbedded in retro-peritoneal tissue. × 15.

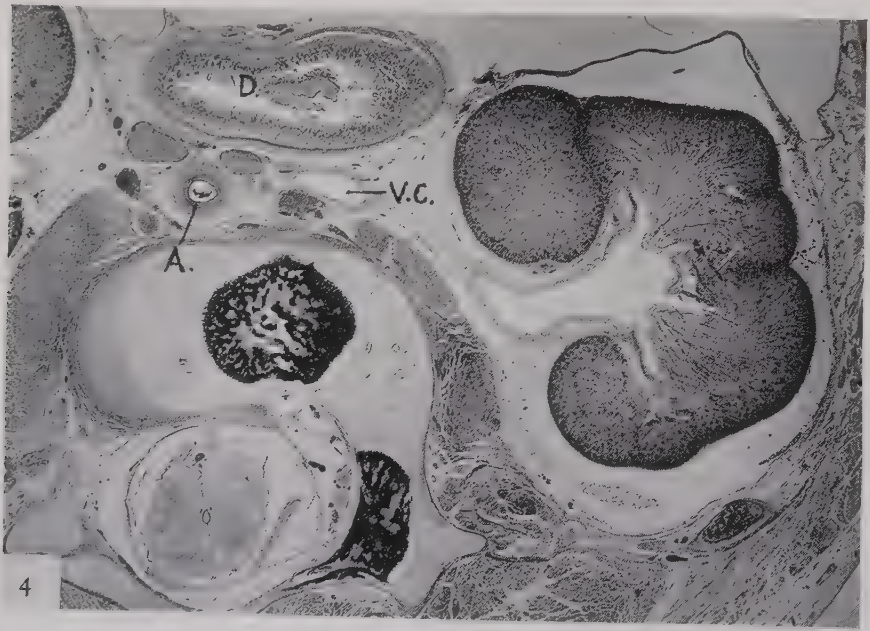


Fig. 4 145-mm. (CRL) embryo. The anterior and posterior renal fasciae are differentiated. Note aorta (A.) and vena cava (V. C.) enclosed in retro-peritoneal tissue. The parietal and mesenterial peritoneal layers have fused as shown around the duodenum (D.). × 7, H and E stain.

and pancreas have fused with the dorsal parietal peritoneum. The ventral surfaces of the anterior renal fascia, therefore, are covered with a single peritoneal layer, resulting from the fusion of the mesenterial peritoneum of the digestive tract with the parietal peritoneum (fig. 4).

7-, 8-, and 9-mo. fetuses. In the specimens of this age group, the fascial layers are well developed; the large, fetal adrenal is still situated mostly over the ventral surface of the kidney in the younger fetuses; and very little peri- or para-renal fat is formed.

In the 7-month fetus (fig. 5) the primitive mesentery of the colon (MDC), with the enclosed blood vessels and nerves, was dissected and freed from the subjacent remains of the dorsal parietal peritoneum and retro-peritoneal tissue (PP and RT). The latter tissue was also separated from the transversalis fascia (TF), demonstrating that the

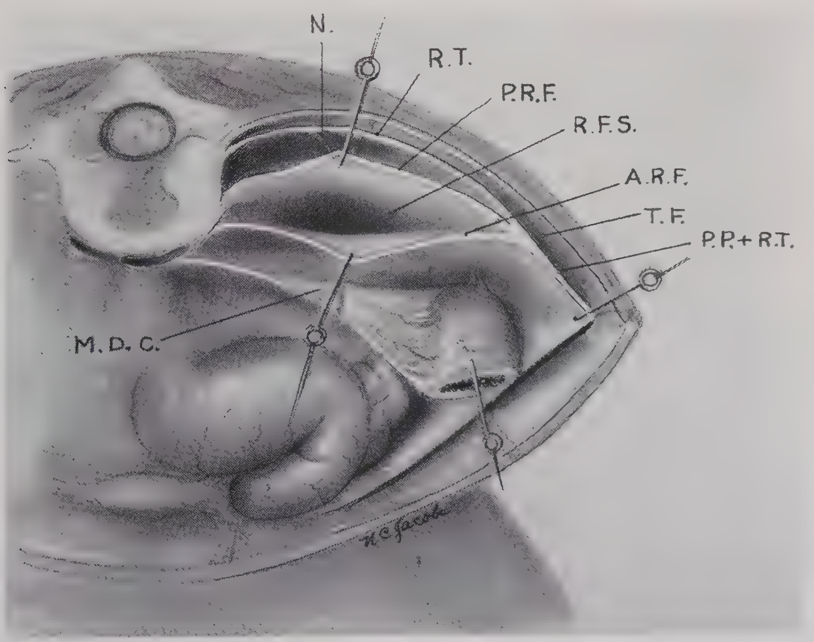


Fig. 5 Cephalic view of left lumbar region of seventh-month fetus. Kidney and renal capsule removed to show renal fascial space (R. F. S.) formed by anterior (A. R. F.) and posterior (P. R. F.) layers of renal fascia which are continuous laterally with remains of parietal peritoneum fused to retro-peritoneal tissue (P. P. and R. T.). This figure also shows: the mesenterial peritoneum (M. D. C.) containing the vessels and nerves of the descending colon, dissected from the anterior renal fascia; the retro-peritoneal tissue (R. T.) continuing dorsal to the posterior renal fascia where para-renal fat will be formed; the transversalis fascia (T. F.) adjacent to the abdominal musculature; and the course of a lumbar nerve (N.). × 2.

anterior renal fascia (ARF) and posterior renal fascia (PRF) and the reto-peritoneal tissue (RT) are not a part of the true transversalis fascia. The anterior and posterior layer of renal fascia fused and became continuous with the retro-peritoneal tissue along the line of connection of the mesentery of the descending or ascending colon to the body wall. In this specimen, the kidney and its capsule have been removed to demonstrate the space formed by the renal fascia (RFS). The dorso-mediad continuation of the transversalis fascia was traced over the quadratus lumborum and psoas muscles to the vertebrae.

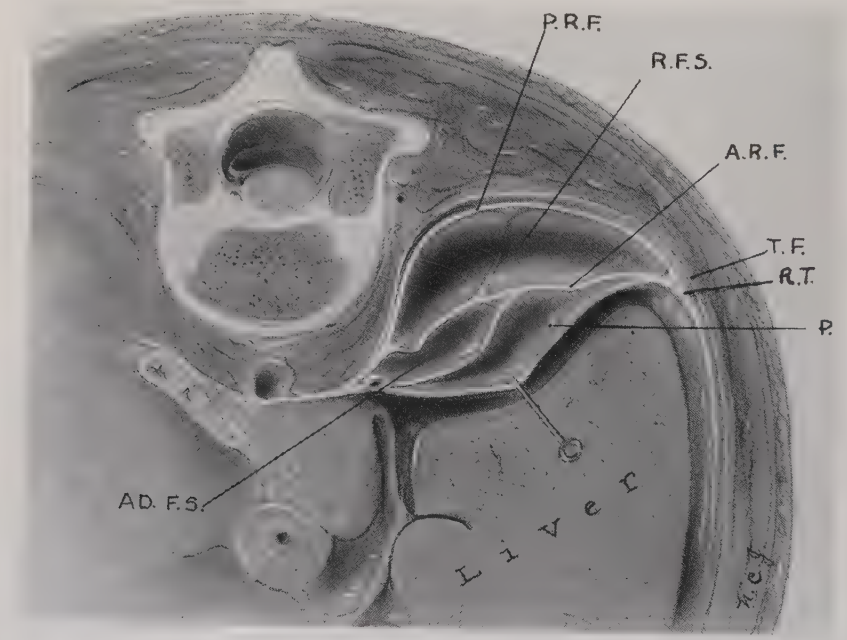


Fig. 6 Caudal view of section from right kidney and adrenal region of eighth-month fetus. Adrenal and kidney, with their capsules, have been removed to show the space formed for the adrenal (AD. F. S.) in the anterior renal fascia (A. R. F.). The relations of the parietal peritoneum (P.), retro-peritoneal tissue (R. T.) and transversalis fascia (T. F.) to the renal fascial space (R. F. S.), formed by the anterior (A. R. F.) and posterior (P. R. F.) renal fasciae are demonstrated. × 2.

The retro-peritoneal tissue, dorsal to the posterior renal fascia, is the site of formation of para-renal fat.

The form of the renal fascia and its relations to the peritoneum, retro-peritoneal tissue and transversalis fascia for the 8-month fetus (fig. 6) and 9-month fetus (fig. 7) were similar to those of the preceding specimen. These sections show the cephalic portion of the right kidney region, from a caudal view, to demonstrate the relation of the renal fascia to the adrenal. In figure 6, both kidney and adrenal with their intrinsic capsules have been removed, showing that the adrenal was located in a fascial space (AdFS) formed in the anterior renal fascia. In figure 7, only the kidney and its capsule were removed. The adrenal had a more cephalic position in this older specimen and therefore both the anterior and posterior layers of renal fascia enclosed the adrenal. However the space formed by the renal fascia for the kidney (RFS) was separated from the adrenal by a thin layer of fascia (fig. 7B)

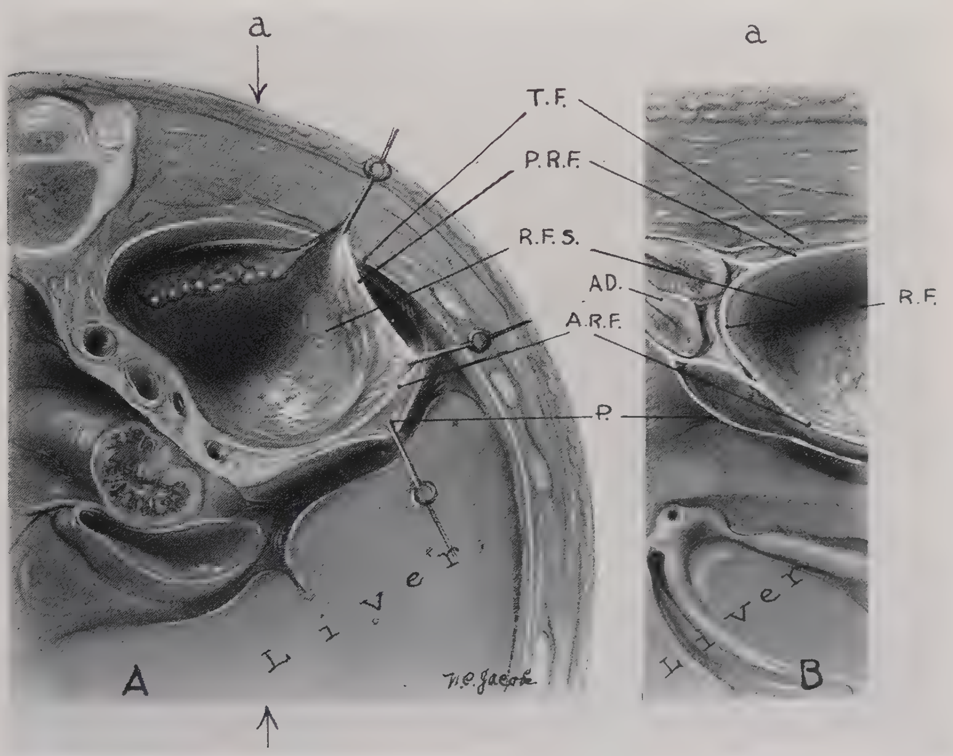


Fig. 7 Caudal (A.) and lateral (B.—cut along line a) views of sections from the right kidney and adrenal region of a ninth-month fetus. Kidney and its capsule have been removed. The adrenal is more cephalic to the kidney than in the younger fetuses, and is enclosed by a continuation of the anterior (A. R. F.) and posterior (P. R. F.) renal fasciae. The adrenal is separated from the renal fascial space (R. F. S.) by a layer of fascia and fat (R. F.). The relationship of the peritoneum and transversalis fascia to the renal fascia are shown. × 1½.

The anterior and posterior layers of renal fascia, in these fetuses, approximated each other at the hilus of the kidney and became adherent to the walls of the renal pelvis and renal vessels. The space formed for the kidney by the renal fascia was potentially closed off from the course of the ureter and from the opposite renal space. Since there was very little peri-renal fat present at this age, very few strands of connective tissue attached the renal capsule to the renal fascia.

2-day-old infant. This infant had a spina bifida, involving the lumbar vertebrae, and a unilateral adrenal and kidney on the right side — with the kidney ectopic and pelvic in position. As shown in figure 8, the peritoneum, transversalis fascia and retro-peritoneal tissue could be dissected as separate layers on the left side but the latter tissue was represented only by a layer of fatty tissue. No tissue comparable to renal fascia could be found in the absence of the kidney and adrenal on this side. The right kidney was enlarged and the anterior renal fascia very thin and closely adherent to the peritoneum of the right side (P and ARF). The posterior layer of renal fascia was also well

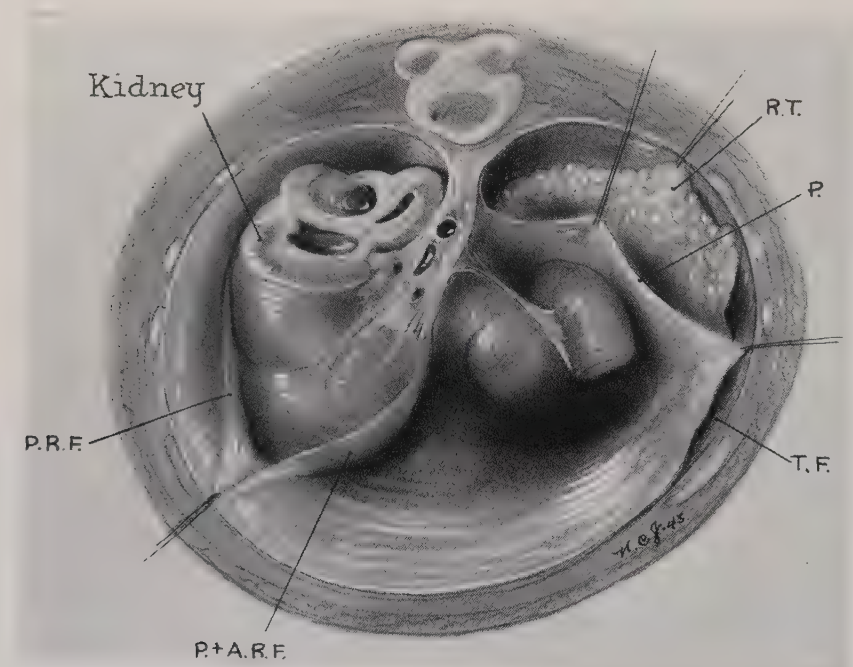
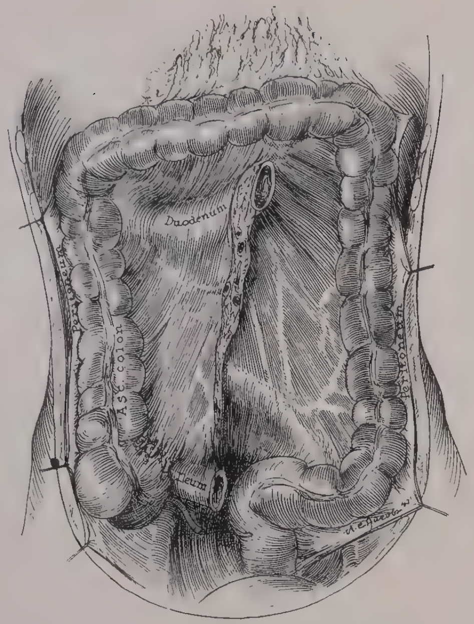


Fig. 8 Cephalic view of cross section from lower abdomen and pelvis of a 2-day-old infant with congenital absence of the left kidney. No renal fascia or peri-renal fat is formed on this side. The retro-peritoneal tissue (R. T.) in the region of the missing kidney is represented only by a layer of fat and connective tissue. The right kidney is enlarged and pelvic in position. Renal fascia on the right side is thin and the anterior layer fused with the peritoneum (P. and A. R. P.) while the posterior layer (P. R. F.) is adherent to the transversalis fascia. × 2.

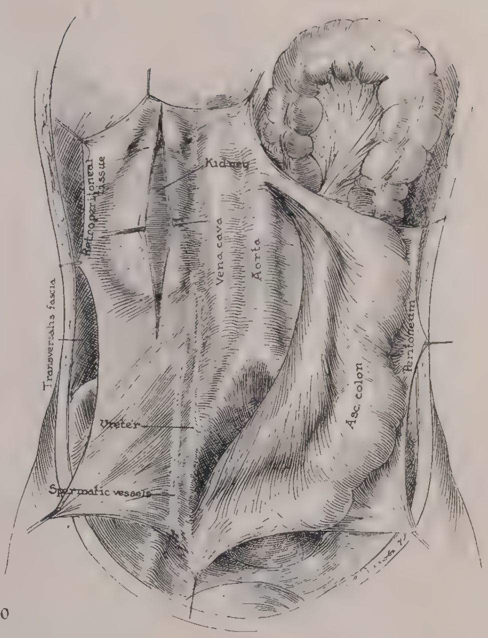
developed. This abnormal specimen is interesting because it demonstrates that the renal fascia is a local condensation of the retro-peritoneal tissue, which forms only when the kidney is present; while transversalis fascia, para-renal fat and peritoneum developed in spite of kidney absence. The retro-peritoneal tissue on the right side had the same relations to the renal vessels, aorta, vena cava, ureter and spermatic vessels, as though this hypertrophied kidney were normal in size and position.

Adult specimens. The structure and extent of the renal fascia of the adult is relatively simple if interpreted on the basis of the above definitions of renal fascia, transversalis fascia, and retro-peritoneal tissue stated above and the concept of stratification of abdominal fascia suggested by Daseler and Anson ('43).

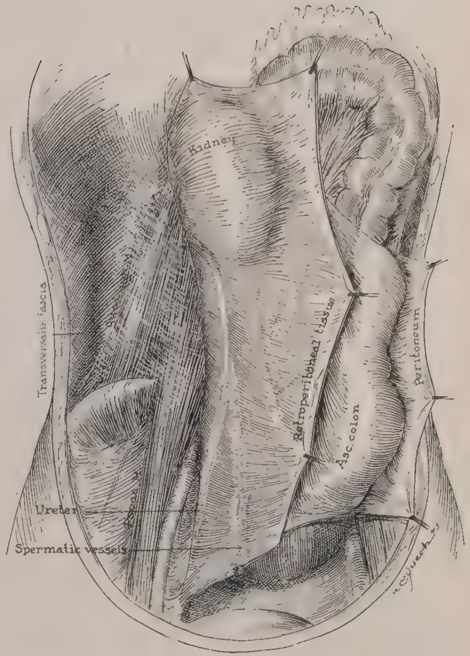
The parietal and visceral peritoneal surface in the caudal two-thirds of the abdominal cavity (jejunum and ileum removed with their mesentery), is shown in figure 9. It was found that if the parietal peritoneum were cut along the mid-axillary line, this peritoneum together with the primitive mesenteries of the ascending and descending colon, duodenum and pancreas, with their vessels, nerves and associated fascia, could be dissected free and elevated from the subjacent retro-peritoneal tissue. In the mid-line the peritoneum could be freed as far cephalad as the superior mesenteric vessels, being adherent to the retro-peritoneal tissue only by the superior and inferior mesenteric vessels and their fascia. With the reflection of the peritoneum, the form and extent of the retro-peritoneal tissue was exposed. It was best developed in the lateral and dorsal part of the abdomen and extended from the pelvic viscera to the inferior surface of the diaphragm. It was separate from the transversalis fascia and covered the aorta, vena cava, renal vessels, kidneys, adrenals, ureters, and spermatic vessels (fig. 10). When this retro-peritoneal tissue was dissected from the transversalis fascia, the above structures were seen to be contained in the former layer and, depending on the obesity of the specimen, varying amounts of fat were located within this retro-peritoneal tissue (fig. 11). The transversalis fascia could be traced dorsad and mediad and was found to cover the intrinsic fascia of the quadratus lumborum and of the psoas muscles. It may be fused with the psoas fascia at the lateral border of the psoas, but is separate from the psoas fascia and can be traced to the side and ventral surfaces of the lumbar vertebrae (figs. 11 and 12). These dissections demonstrate clearly the three strata of abdominal fasciae.


Duodenum
Peritoneum
Asc. colon
Peritoneum
Ileum

9


Retroperitoneal tissue
Kidney
Vena cava
Aorta
Transversalis fascia
Peritoneum
Asc. colon
Ureter
Spermatic vessels

10


Kidney
Transversalis fascia
Retroperitoneal tissue
Peritoneum
Asc. colon
Psoas
Ureter
Spermatic vessels

11

Fig. 9 Drawing of visceral and parietal peritoneum associated with large intestine (jejunum and ileum with their mesenteries removed). Peritoneum cut along mid-axillary line. $\times \frac{3}{4}$.

Fig. 10 Parietal and mesenterial peritoneum, containing vessels and nerves of ascending colon reflected to the left side of the abdomen. Retroperitoneal tissue covers the spermatic vessels, ureters, vena cava and aorta and is continuous across the mid-line between the superior and inferior mesenteric vessels. This tissue is cut to show that the anterior renal fascia is a local condensation of the retro-peritoneal tissue covering the kidney and adrenal. $\times \frac{3}{4}$.

Fig. 11 The retro-peritoneal tissue is elevated and reflected to the left side to show the ureter and spermatic vessels are imbedded in this tissue. The posterior layer of renal fascia is part of the retro-peritoneal tissue. The transversalis fascia is a distinct layer immediately adjacent to and covering the inner surfaces of the Mm. transversus abdominis, quadratus lumborum and psoas. $\times \frac{3}{4}$.

The anterior layer of renal fascia was found to be a condensation of the collagenous-elastic components of the retro-peritoneal tissue as shown by cutting this tissue over the ventral surface of the kidney (fig. 10). The anterior renal fascia was a thin layer which was continuous over the mid-line of the body to cover the ventral surfaces of the kidneys, adrenals, renal vessels, aorta and vena cava. The thicker posterior layer had a similar course and extent but also was attached to the ventral surfaces of the bodies of the vertebrae (figs. 11 and 12). These layers extended from the lateral and inferior borders of the kidney to the cephalic border of the adrenal, where they fused and became continuous with the retro-peritoneal tissue covering the ventral surface of the diaphragm. The anterior and posterior layers of renal fascia approximated each other at the hilus of the kidney and were attached to the renal vessels and ureter. Therefore the renal fascial space of one side does not communicate with that of the other side.

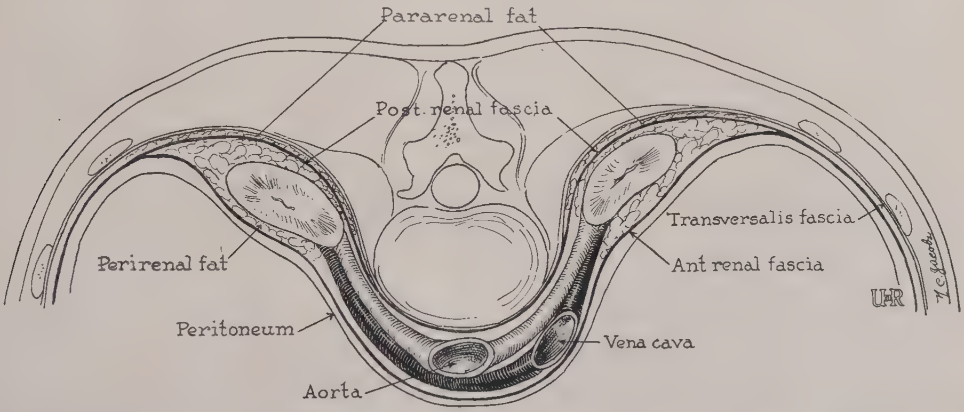


Fig. 12 Cephalic view of a transverse section, dissected to show the relation of the renal fascia to the renal vessels, aorta and vena cava and peri-renal fat. The para-renal fat is between the posterior renal fascia and transversalis fascia. × 1.

The peri-renal fat was smaller in amount over the ventral surface of the kidney than over its lateral and dorsal surfaces. Strands of interlacing connective tissue permeating this fat and connecting the renal capsule to the anterior and posterior layers of renal fascia, were particularly well developed at the cephalic pole of the kidney. Over the ventral surface of the kidney the fat-containing tissue may be in the form of a fibrous layer paralleling the renal capsule, between it and the renal fascia, in specimens of slight obesity. The para-renal fat likewise interlaced by connective tissue septae, was located between the posterior layer of renal fascia and the transversalis fascia (fig. 12) and was continuous laterally with the retro-peritoneal fat of the abdominal wall.

The abdominal courses of the ureter and spermatic vessels were enclosed within the retro-peritoneal tissue (figs. 3, 10 and 11). This tissue becomes thinner near the pelvic brim but could be followed to the bladder, corroborating the description given by Hinman ('35) that part of the renal fascia is continued along the ureter to the bladder. Whether the tissue surrounding the ureter and spermatic (or ovarian) vessels was a caudal continuation of the renal fascia or merely a part of the retro-peritoneal tissue, depended on the obesity of the specimen. In cases where the peri-renal fat was well developed, this fat and the anterior and posterior layers of renal fascia formed coverings for the ureter and spermatic vessels. In cases of lesser obesity, their covering appeared to be merely collagenous-elastic components of the retro-peritoneal tissue.

DISCUSSION

The inadequacy of some of the published descriptions of the renal fascia appears to be due to the different meanings associated with the term fascia (Congdon and Edson, '41) and to the tissue from which the renal fascia is derived. Daseler and Anson ('43), in describing the renal fascia for ectopic or normally placed kidneys, suggested a stratification of the abdominal fascia into three layers — one for the ventrally placed digestive tube and its vessels and nerves; an intermediate layer for the kidneys, adrenals, ureters and their associated vessels and nerves, together with the aorta and vena cava; and a dorsal layer for the parietal musculature with its nerve and blood supply. A developmental basis for the stratification of abdominal fascia has been traced in these studies.

The renal fascia develops from a layer of mesenchyme which later differentiates into: a thin layer of connective tissue associated with the peritoneum, vessels and nerves of the digestive tube; a dense fascial layer adjacent to the abdominal musculature (the transversalis fascia); and an intermediate layer, the retro-peritoneal tissue, which contains the kidneys, adrenals, renal vessels, aorta, vena cava, spermatic vessels and ureters in a common layer. The retro-peritoneal tissue may be fascial, fibrous or adipose in different parts of the abdomen — the amount of the various components depending on the obesity and body-type of the adult individual.

The renal fascia appears to be formed from local condensation of retro-peritoneal tissue. If the kidney is absent, the renal fascial layers are not formed and the retro-peritoneal tissue, in the area of the missing kidney, is represented only by fat and connective tissue. The anterior and posterior lamina of renal fascia retain the same relations to the aorta, vena cava, renal vessels, kidney and adrenal of each side, as the tissue from which this fascia is derived had to these structures. However in the adult, the renal fascia becomes adherent to the renal pelvis and vessels obliterating a direct communication between the renal fascial spaces of the two sides across the mid-line of the body.

The retro-peritoneal tissue, caudal to the kidney, also remains as a layer enclosing the aorta, vena cava, ureter and spermatic vessels. The tissue associated with the ureter and spermatic (or ovarian) vessels may be either fibrous in specimens of slight obesity, or could be interpreted as a part of the renal fascia, if the specimen were obese and had well developed laminae of renal fascia enclosing a large amount of peri-renal fat. The renal fascia should be considered as part of the retro-peritoneal tissue and therefore varying with the form of this tissue.

The connective tissue strands, permeating the peri-renal fat and connecting the renal capsule to the renal fascia of the adult, appear to be derived from retro-peritoneal tissue before the peri-renal fat develops in this tissue and while the intrinsic renal capsule surrounding the lobules of the fetal kidney is still adjacent to the developing renal fascia. In the absence of a large amount of peri-renal fat, the connective tissue may have the form of a delicate membrane paralleling the surface of the renal capsule.

CONCLUSIONS

1. The kidneys, adrenals, renal vessels, aorta, vena cava, spermatic (or ovarian) vessels and ureters, in the embryo are enclosed in a common layer of mesenchyme, intermediate in position between the mesenchyme of the digestive tube and abdominal musculature, which differentiates into a layer designated as retro-peritoneal tissue.

2. The retro-peritoneal tissue is fascial, fibrous or adipose in structure in various parts of the abdomen and is located between the peritoneum and transversalis fascia. It extends from the pelvis to the diaphragm and is best developed in the lateral and dorsal part of the abdomen. The amount of adipose or fibrous tissue in this layer varies with the obesity of the specimen. The retro-peritoneal and para-renal fat are contained in this tissue. The peri-renal fat is found within the envelope formed by the renal fascia.

3. The transversalis fascia is immediately adjacent to the Mm. transversus abdominis, quadratus lumborum and psoas. It is distinct from the intrinsic fascia of these muscles and attaches to the bodies of the lumbar vertebrae. A fusion of the transversalis and psoas fasciae may be formed at the lateral border of the psoas muscle.

4. The renal fascia appears to be derived from a local condensation of the retro-peritoneal tissue and not from the transversalis fascia. The anterior and posterior lamina of renal fascia form an envelope enclosing the kidneys, adrenal and peri-renal fat of each side in a space which is subdivided by a thin layer of connective tissue and fat, separating the kidney from the adrenal. Fibrous, connective-tissue bands permeate the peri-renal fat connecting the renal fascia to the intrinsic kidney capsule. The para-renal fat is located in a dorsal continuation of the retro-peritoneal tissue, external to the posterior layer of renal fascia.

5. In congenital absence of the kidney, the renal fascia does not develop.

6. The layers of renal fascia approximate each other at the hilus of the kidney, enclose and are adherent to the renal pelvis and vessels, aorta and vena cava and become continuous with corresponding layers of the opposite side.

7. The ureter and spermatic (or ovarian) vessels are enclosed in a layer of tissue which could be interpreted as a caudal continuation of the renal fascia in obese specimens, or as retro-peritoneal connective tissue in specimens of lesser obesity. Caudal to the kidneys, the aorta and vena cava are enclosed in the fibrous components of the retro-peritoneal tissue.

ACKNOWLEDGMENT

The author is indebted greatly to Dr. John A. Benjamin, Department of Surgery (Division of Urology), The University of Rochester School of Medicine and Dentistry, and to Dr. E. J. Komora, formerly of Veterans Administration, Batavia, N. Y., now with the Medical Corps, A. U. S., for their suggestions and criticisms of this work.

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THE HEART BEAT OF AVIAN EMBRYOS

ALEXIS L. ROMANOFF
Agricultural Experiment Station, Cornell University, Ithaca, New York

FOUR FIGURES

The rate of heart beat has long been used as an indicator of the functioning of the organ itself, and, indirectly of other normal and pathological conditions within the embryo. It has been shown that during the development of fish, birds and reptiles (Needham, '31) the rate of heart beat changes regularly.

Studies of the avian heart have been made exclusively on chick material under both normal and pathological conditions, particularly in relation to the effect of temperature on the rate of heart beat. The extensive literature on this subject has already been reviewed (Romanoff, '29; Parpart and Glaser, '30; Romanoff and Sochen, '36; Alexander and Glaser, '41).

Although a great deal of work has been done on the heart heat of chick embryos, very little is known about it in other species. It would be of interest to know whether changes in the rate of heart beat in embryos of other gallinaceous birds are identical with that of the chick. For that reason two other species of birds, Ringnecked pheasant (Phasianus torquatus) and Bobwhite quail (Colinus virginianus), were studied for comparison with White Leghorns (Gallus gallus).

METHODS

Observations were made at daily intervals by the method previously described (Romanoff and Sochen, '36) in which an observation box was used that permitted accurate control of temperature and humidity, and viewing the embryo, through a window made in the shell, either directly or by means of a low power microscope. The rate of heart beat was recorded by a hand-counter and timed with a stop watch. The majority of recordings were made on different embryos, but some were taken of the same embryo on successive days. The latter method required the cultivation of the embryo in an opened egg (Romanoff, '31).

The rate of beating of the heart was measured from the second day of embryonic age up to the time of the initiation of the pulmonary respiratory mechanism and cessation of the allantoic circulatory system. This transition from the embryonic to post embryonic life of the bird usually occurs in the chicken on the twentieth day and in the pheasant and quail on the twenty-third day of incubation.

RESULTS AND DISCUSSION

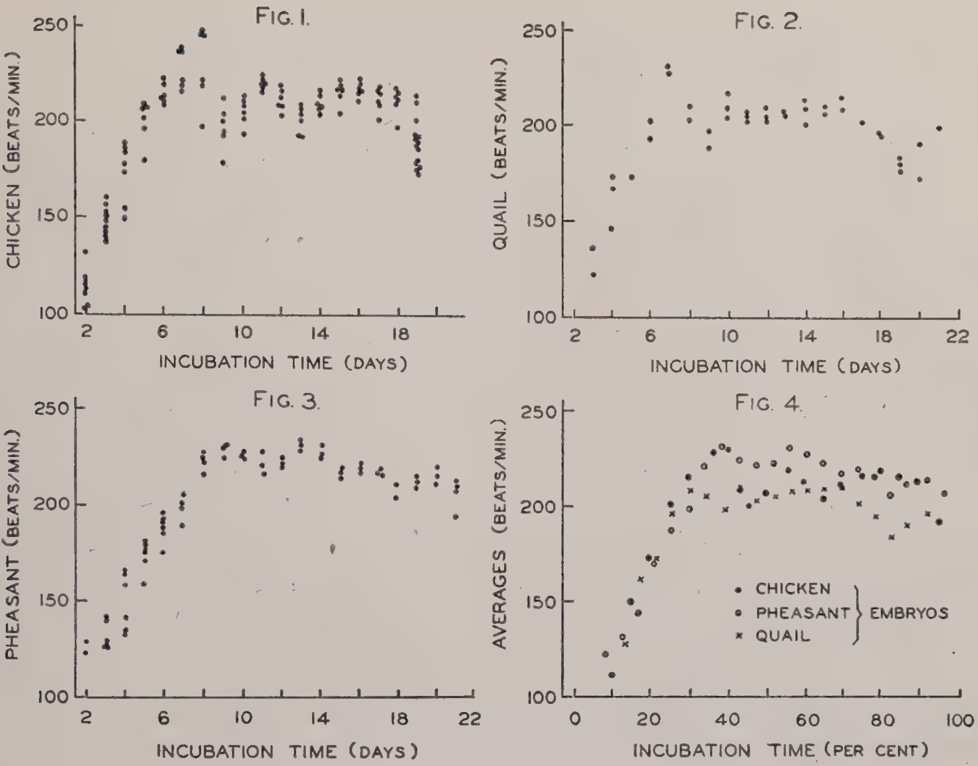
It has been shown that the first rhythmic contractions of the heart in the chick embryo usually occur at about the thirtieth hour (Barry, '40), although the complete vascular circuit is not established before the fortieth hour (Patten and Kramer, '33).

From the beginning up to the forty-eighth hour the rate of pulsation of the heart accelerates most rapidly(Barry, '40). Our data show that after 48 hours there is still acceleration in the rate of heart beat, but much less rapid, and on the eighth or ninth day the heart attains a fairly steady rate of contraction. In fact, there is a slight decline in the rate of heart beat up to time of hatching.

It is of interest to note that there was a considerable similarity in the trend of changes of the rate of heart pulsation in all three species observed — chicken, pheasant and quail (figs. 1, 2, 3 and 4). From a little over 100 beats per minute at the forty-eighth hour, it rose to about 220 beats per minute on the eighth or ninth day. After reaching this peak, the rate fell slowly giving the lowest value of about 200 beats per minute, just before hatching.

There is, of course, a considerable variation in the rate of heart beat between individual embryos (cf. figs. 1, 2 and 3). Also the slight variation in incubating temperature prior to observation may be responsible for minor shifts in the peaks or differences in the heart beat levels among the three species observed (cf. fig. 4).

This study suggests that it would be of particular interest to determine the level of heart beat and changes in rate with the development of Anseriformes, such as duck and goose, or Columbiformes (pigeon) and Passeriformes (song birds). There are differences among these groups of birds in the chemical composition of eggs, the rate of embryonic growth and state of development at the time of hatching, and the level of body temperature of adults, indicating the rate of metabolism.



Figs. 1 to 4 Changes in the rate of heart beat of the developing avian embryo — chicken (fig. 1), quail (fig. 2) and pheasant (fig. 3).

Each dot represents the average of several observations on the same embryo. In figure 4 the averages of daily observations on three species of birds are plotted, for comparison against the entire developmental period, considered as a unit equal to 100%.

SUMMARY

These observations show that the changes in the rate of heart beat of the developing embryo are nearly identical in all species of gallinaceous birds studied (chicken, pheasant and quail).

For the first third of the developmental period, from the second day on, the rate of heart beat increases very rapidly up to about 220 beats per minute. Then it begins to fall slowly until, close to hatching time, when it reaches about 200 beats per minute.

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DEVELOPMENT OF THE TESTIS IN THE RING-NECKED PHEASANT[1]

C. M. KIRKPATRICK AND F. N. ANDREWS
Department of Forestry and Conservation and Department of Animal Husbandry,
Purdue University, Lafayette, Indiana

ONE TEXT FIGURE AND ONE PLATE (FOUR FIGURES)

In most vertebrates the production of mature spermatozoa is not a continuous process but tends to be limited to a particular season of the year. With a few possible exceptions spermatogenesis is a seasonal phenomenon in wild species of birds, and even in the domestic fowl which has been selected for continuous reproduction, season still influences semen production. (Wheeler and Andrews, '43).

Studies of spermatogenesis in several species of passerine birds have revealed that season has a definite influence upon testicular activity. The reports of Rowan ('29) on the junco (Junco hyemalis), Bissonnette and Chapnick ('30) on the starling (Sturnus vulgaris), Kirschbaum and Ringoen ('36) on the sparrow (Passer domesticus), Blanchard ('41) on the white-crowned sparrow (Zonotrichia leucophrys), Wolfson ('42) on the Oregon junco (Junco oreganus), and others have shown, in general, that spermatogenesis and testis size are closely correlated, that testes of minimal size and activity are found during the fall and winter months, that testis size and spermatogenic activity are maximum in the spring and early summer, and that testicular involution begins in the summer and continues until the testis becomes inactive in the fall.

Because of the technical difficulties involved the relationships of age and testicular development have not been investigated in wild birds. In the domestic fowl Hogue and Schnetzler ('37) reported that in the Barred Plymouth Rock the seminiferous tubules were composed chiefly of spermatogonia during the first 8 weeks of life. Testis weight was approximately doubled between the eighth and twelfth weeks and primary and secondary spermatocytes were observed. At 18 weeks of age the testis weights were similar to those of mature males and fully formed spermatozoa were present. Parker et al. ('42) found that in White Leghorn and New Hampshire males rapid testicular development was initiated between the eighth and twelfth weeks and that mature testis size was approached at 24 and 30 weeks in Leghorns and New Hampshires respectively. Spermatids were not present in either breed at 8 weeks but spermatozoa were observed in both at 12 weeks of age.

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[1] Journal Paper number 155, of the Purdue University Agricultural Experiment Station, the Indiana Department of Conservation cooperating. The data in table 1 were used in a thesis presented to the University of Wisconsin Graduate School by the senior author in partial fulfillment of the requirements for the Doctor of Philosophy degree.

Although it has long been known that the ring-necked pheasant (Phasianus colchicus torquatus) is a seasonal breeder, the development and function of the testis has not been investigated. In a preceding paper dealing with this species Kirkpatrick ('44) reported on the relation of age and season to body weights and to growth of organs (including gonads). The testis material was reserved for more intensive study and is presented below.

MATERIALS AND METHODS

The testes of eighty normal ring-necked pheasants ranging in age from 16 to 362 days were immediately removed at the time of autopsy, weighed, and fixed in Bouin's fluid. They were subsequently dehydrated in butyl alcohol, sectioned at 8 microns, and stained in hematoxylin and eosin. Preparations from seventy-two birds were studied histologically and findings recorded in figure 1.

RESULTS

The influence of age on testis weight is summarized in table 1. The development of the gonads, as measured by weight, appeared to be characterized by four fairly well defined stages, of which the fourth is the most conspicuous (cf. Kirkpatrick, '44, fig. 2). Since the number of pheasants observed in each age group is small the range in age of each of the four growth phases should be considered as an approximate rather than an absolute limit and it is recognized that considerable individual variation exists. The first growth phase was characterized by a very gradual increase in testis weight and appeared to end somewhere between the fifty-sixth and eighty-first days after hatching. The second stage, from the eighty-first to the one hundred forty-fourth days, was one of rapid increase in testis weight. This was followed by a period of involution and decreased gonad weight which extended from soon after the one hundred forty-fourth to the two hundred thirty-sixth day of age. The fourth, and most important phase of development, the attainment of mature testis size and full spermatogenesis, was initiated at approximately 236 days of age and was completed at about 334 days. This final stage of development represents the period of seasonal spermatogenesis in the ring-necked pheasant and occurred in the latter part of March, April, and May.

TABLE 1

Growth and involution of gonad, thymus, and bursa in the male ring-necked pheasant.

AUTOPSY *Date*	AGE *(Days)*	TESTIS WT.[2] *(Grams)*	THYMUS WT.[2] *(Grams)*	BURSA DEPTH [2] *(Millimeters)*
6/5/41	16	.003 (1)	.140 (1)	11.6 (3)
6/17	28	.010 (3)	.499 (3)	16.5 (4)
7/3	43	.018 (1)	.515 (1)	
7/8	49	.023 (1)	1.280 (1)	17.0 (4)
7/15	56	.031 (3)	1.200 (3)	17.5 (2)
8/3	75	.084 (3)	1.230 (2)	15.6 (3)
8/9	81	.175 (1)	1.540 (1)	16.6 (3)
8/15	87	.115 (3)	1.780 (3)	20.0 (1)
8/22	94	.359 (3)	2.210 (3)	20.5 (2)
8/29	101	.154 (2)	3.300 (2)	18.6 (3)
9/6	109	.400 (3)	2.160 (3)	22.5 (2)
9/13	116	.254 (2)	1.550 (2)	20.3 (3)
9/27	130	.280 (2)	2.400 (2)	19.0 (2)
10/11	144	.264 (2)	1.420 (2)	20.0 (2)
10/18	151	.194 (2)	1.080 (2)	18.5 (2)
11/1	165	.164 (2)	.352 (2)	17.0 (2)
11/8	172	.178 (2)	.283 (2)	16.5 (2)
11/27	191	.162 (4)	.129 (3)	15.0 (3)
12/22	215	.167 (5)	.126 (2)	13.5 (5)
1/12/42	236	.210 (5)	.168 (1)	12.8 (5)
2/2	257	.271 (5)		7.0 (4)
2/16	271	.990 (5)		7.0 (5)
3/2	285	1.840 (5)		7.2 (5)
3/23	306	8.220 (5)		3.8 (5)
4/20	334	11.960 (5)		0.0 (4)
5/18	362	10.400 (5)		0.0 (4)

The histological study of the testis revealed that spermatogenic activity is closely correlated with the four growth phases previously described. These data are schematically presented in figure 1. The presence of primary and secondary spermatocytes, spermatids and spermatozoa is indicated by vertical bars. Spermatogonia appeared at all stages.

During the first 81 days the seminiferous tubules were composed of well organized spermatogonia and a few scattered primary spermatocytes (fig. 2). Between the eighty-first and one hundred forty-fourth days inclusively there was a marked increase in spermatogenesis. In six of eighteen testis sections studied secondary spermatocytes were observed and in three of the birds spermatozoa were present (fig. 3). From the one hundred forty-fourth to the two hundred fifty-seventh days the seminiferous tubules showed little activity and contained only spermatogonia and a few primary spermatocytes (fig. 4). With the marked increase in testicular weight at about the two hundred seventieth day, the rate of spermatogenesis was greatly increased. Primary and secondary spermatocytes and spermatids developed in rapid succession and spermatozoa appeared in large numbers (fig. 5).

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[2] Figures within parentheses are number of birds observed for that age.

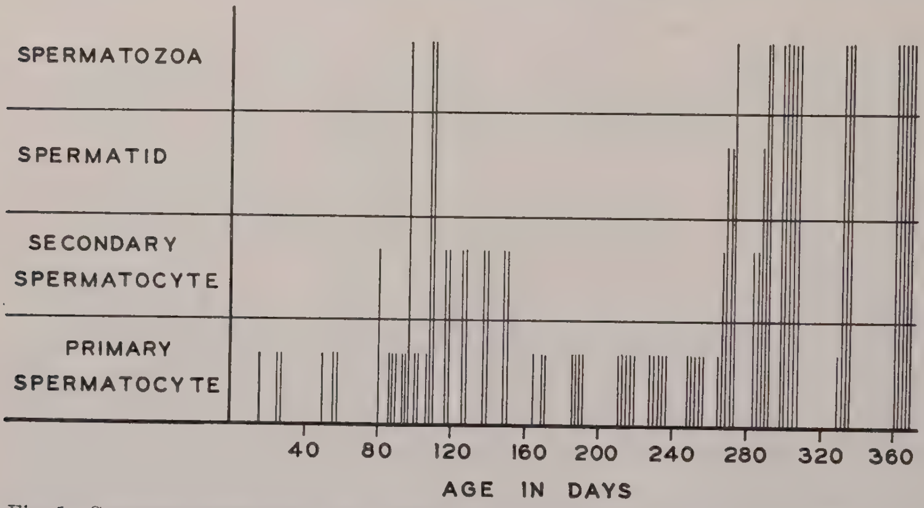

Fig. 1 Spermatogenesis in the ring-necked pheasant in relation to age. The most advanced germinal elements in each pheasant are indicated by the height of the vertical bars.

DISCUSSION

The data presented in this study on the ring-necked pheasant are similar to the findings of others in passerine birds in that there is a definite seasonal period of full spermatogenesis. The results were similar to those reported in the domestic fowl in that there was a period of increased spermatogenic activity beginning about the twelfth week. In the domestic fowl full spermatogenesis is attained between the eighteenth and thirtieth weeks and is then maintained at a more or less continuous rate during the entire reproductive life of the cock. The fact that the rate of spermatogenesis is temporarily increased at approximately the twelfth week in the pheasant, and that spermatozoa may be produced is highly suggestive that present strains of domestic fowls exhibited similar characteristics prior to the intensive selection which has been practiced in recent years. Furthermore, it suggests that a similar period of spermatogenic activity might occur in some native gallinaceous birds to explain their unseasonal behavior which is normally associated with the breeding season courtship. For example, ruffed grouse (Bonasa umbellus) are known to drum at all seasons (Allen, '34) and have been known to copulate in autumn (Forbush, '27). Wisconsin prairie chickens (Tympanuchus cupido americanus) were observed to boom sporadically in mid-October (Hammerstrom, '39), and fall booming might have been indulged in by the now extinct heath hen (Tympanuchus c. cupido) as reported by Gross ('28). The sage grouse (Centrocercus urophasianus) sometimes struts in November although the mating season is from March to June (Scott, '42).

As previously described (Kirkpatrick, '44) and as summarized in table 1, the weight of the thymus gland and the depth of the bursa reach maxima between 100 and 130 days and the involution of both organs begins immediately after this period. It is of considerable physiological interest that involution should be initiated during the interval when testis size and activity are temporarily increased. It has been subsequently found (Kirkpatrick and Andrews, '44) that the injection of testosterone propionate into normal and castrate male pheasants and of stilbestrol into normal females produces highly significant decreases in bursa depth in sexually immature pheasants. The data at hand therefore suggest that there may be a physiological relationship between the stimulation of the testis at about 100 days of age and the subsequent involution of the thymus and bursa. This hypothesis is in harmony with Riddle's ('28) observation that in the dove the increased rate of growth of the gonads is coincident with beginning involution in the bursa and thymus.

SUMMARY

Histological study of a series of pheasant testes revealed that spermatogenesis is closely correlated with four testicular growth phases. The first phase, from hatching until between the fifty-sixth and the eighty-first days, was characterized by a gradual increase in weight and seminiferous tubules composed of spermatogonia and a few primary spermatocytes. The second stage, from the eighty-first day until the one hundred forty-fourth day, was one of rapid increase in weight and the production of spermatozoa in three of eighteen testes observed during this period. The third stage, from after the one hundred forty-

fourth day to after the two hundred thirty-sixth day was one of testis involution and the seminiferous tubules contained only spermatogonia and a few primary spermatocytes. The final developmental stage and the attainment of mature testis size and full spermatogenesis was initiated at approximately the two hundred fifty-seventh day. Full breeding condition of the testis was maintained through the three hundred sixty-second day when the last autopsy was made.

The pheasant is similar to passerine birds in having a definite seasonal breeding period, but an interval of spermatogenic activity in late summer juveniles is paralleled by the precocious spermatogenesis in the domestic fowl at the same age (8 to 12 weeks). A number of native grouse is also known to show indications of sexual activity in fall or early winter.

Both thymus and bursa reached maxima between 100 and 130 days after which involution of both organs began at once. This was the same period when testis size and activity were temporarily increased suggesting a physiological relationship between stimulation of the testis at about 100 days and the subsequent involution of thymus and bursa.

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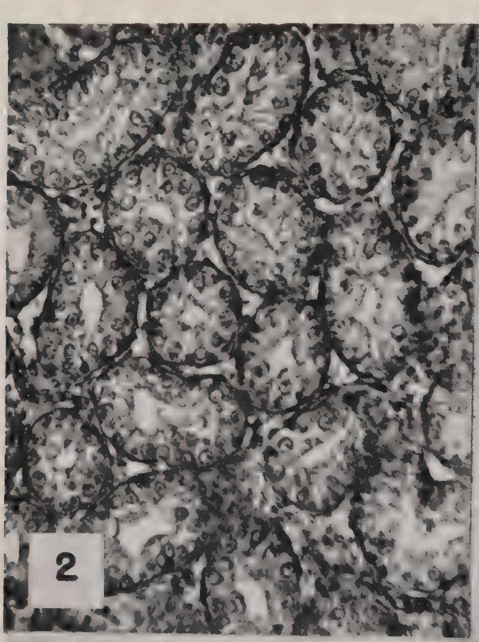

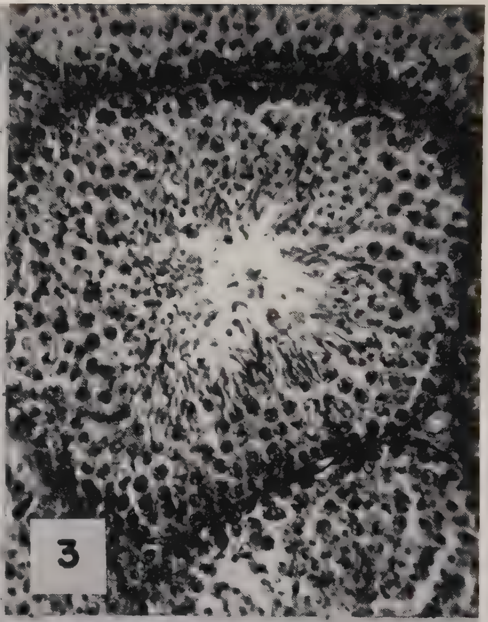

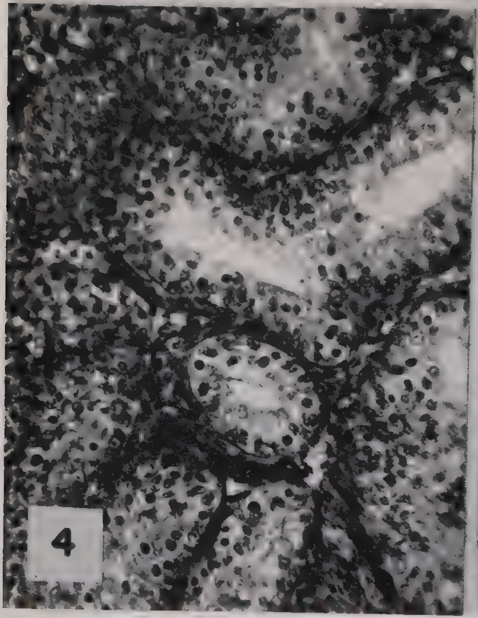

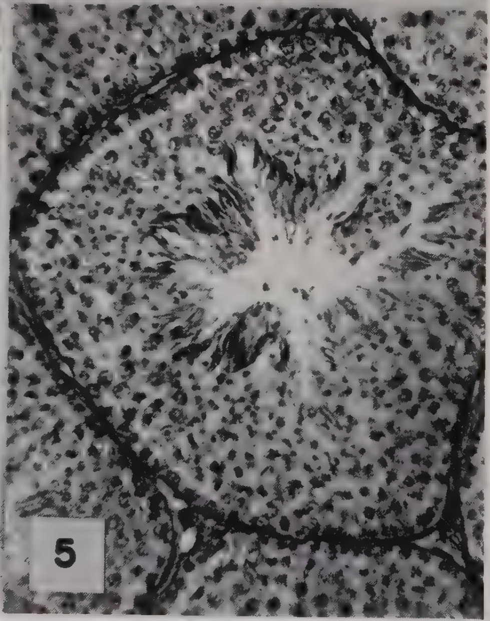

2 Seminiferous tubules of 56-day-old pheasant on July 15th contain spermatogonia and a few primary spermatocytes. × 220.

3 Testis of a 109-day-old bird on September 6th, shows numerous spermatozoa. × 220.

4 Spermatogonia and primary spermatocytes are present in the tubules of a 125-day-old male on December 22nd. × 220.

5 Complete spermatogenesis in a 362-day-old male on May 18th. × 220.

BREEDING AND REARING OF YOUNG BY ALBINO RATS SUBJECTED TO AUDITORY STIMULATION[1]

EDMOND J. FARRIS AND ELEANOR H. YEAKEL
The Wistar Institute of Anatomy and Biology, Philadelphia, Pennsylvania

In studying the effect upon rats of long-term exposure to the sound of an air-blast, we have included an investigation of the ability of these animals to breed and to raise young. In similar experiments Maier and Glaser ('40) reported difficulty in mating male rats that exhibited typical running attacks and convulsions of auditory origin, and Patton ('41) noted that some females were more liable to such seizures when lactating. The present paper compares the breeding and rearing of litters by control and air-blasted albino rats.

PROCEDURE

Sixty control and sixty-four experimental virgin female albino rats from The Wistar Institute stock colony were used in this experiment. They were selected from two age groups, 74 to 191 and 300 to 345 days of age, as shown in table 1. All experimental animals were subjected to the sound of an air-blast 5 minutes daily on 5 consecutive days a week. This procedure was begun when the rats were weaned and was continued throughout the investigation. The method of stimulation was described previously (Farris and Yeakel, '42). Experimental and control rats were handled, fed, and cared for in the same manner.

Experimental females in groups of not more than six were placed in dormer cages, and comparable groups of control females (most of them litter mates of the air-blasted rats) were housed similarly in another room. With each set of experimental females was placed one experimental male of the same age range, while a control male (a litter-mate of the experimental male) was mated with the corresponding control female set.

Two weeks after the last litter was weaned, the experiment was repeated, using the same animals and in the same combinations. During the first trial the males were left with the females for 5 days, removed over the weekend, and returned for 5 days. On repetition of the experiment, the males were placed with one group of the females for 5 days, then shifted to another group during the following week.

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[1] Aided in part by a grant from the Samuel S. Fels Fund.

Air-blasting of the experimental males and females was continued throughout both breeding trials, the intervening rest period, gestation and suckling.

When females were found to be pregnant, they were removed to individual cages and were undisturbed except for the daily air-blasting. All cages were inspected for new litters in the morning and late afternoon. The young were counted and weighed as soon as discovered. No record was made of the presence or absence of milk in the stomach of the young, but almost all of them had been suckled when first examined.

RESULTS

Age ranges of the rats at different matings are shown in table 1, while table 2 presents a summary of litter production in the younger age group only. All of the oldest females (group 2), whether experimental or control, apparently failed to become pregnant during the first two matings. Body weights recorded periodically showed no significant increases, and plugs or placental signs were not observed on occasional inspection. A third attempt to breed these females at ages ranging from 397 to 442 days with younger group I males known to be good breeders resulted in two pregnancies. One experimental female gave birth to one dead embryo. Plugs were noticed in three other cases, but no litters were produced. A control female in this age group also had a litter, consisting of four living and two dead rats. A plug

TABLE 1

		FIRST MATING		SECOND MATING		THIRD MATING	
		No. of females	Age range (days)	No. of females	Age range (days)	No. of females	Age range (days)
Group 1	Air-blasted	46	74–191	47	143–261		
	Control	42	74–191	41	143–261		
Group 2	Air-blasted	18	300–345	17	369–414	17	397–442
	Control	18	308–345	16	377–414	14	405–442

TABLE 2

	NO. OF POSSIBLE PREGNANCIES FROM 2 MATING TRIALS	PREGNANCIES		AVG. NO. YOUNG PER LITTER AT BIRTH		PERCENTAGE SURVIVAL		AVG. WT. (GR.) OF YOUNG AT BIRTH	
		No.	%	Total	Alive	1st day	21st	Total	Alive
Air blasted	93	62	66.7	8.6	7.5	87.4	69.7	5.5	5.6
Control	83	31	37.3	9.0	8.9	98.0	66.9	5.6	5.6

was seen in one other control female, but apparently she did not become pregnant.

The percentage of pregnancies recorded in table 2 indicates that the air-blasted animals mated successfully more frequently than did the controls. The number of pregnancies in the experimental females exceeded those of the controls by 30%, with two-thirds of the former group becoming pregnant, and only a little over one-third of the latter group. Statistically this difference is highly significant. The value for Chi square derived from a 2 × 2 contingency table was found to be 15.13, which indicates a probability of this difference occurring by chance once in 10,000 times (Fisher, '30).

Weights of the litters and the total number of animals per litter, recorded from 0 to 16 hours after birth, were approximately equal for control and experimental groups (table 2). However, more dead young were found in experimental litters. It could not be determined, in all cases, whether the young were born dead or succumbed after parturition, but some tendency to failure of normal maternal instinct was observed. Several experimental mothers did not remove the amniotic sacs from all of the young; some either ate the offspring or did not suckle them. Very few of the control females destroyed or obviously neglected their litters. A difference of about 10%, in favor of the controls, occurs in percentage survival of offspring on the first day of life. This difference is statistically significant, and would not occur by chance in over 10,000 trials. At weaning age, the percentage survival was approximately the same.

DISCUSSION

The number of pregnancies in experimental females indicates that animals subjected to the sound of an air-blast became pregnant more readily, when mated with males similarly treated, than did the controls. These females produced a normal number of young, but seemed to bear them less successfully and care for them less efficiently. It would appear that the experimental procedure encouraged sexual receptivity, but depressed maternal behavior at parturition.

The third mating test, breeding the 400-day-old group 2 females with younger males (table 1), shows that although these old virgin rats were past the period of greatest fertility, a few of them mated, and two were capable of producing young. The failure to do so in the first two matings suggests default on the part of the elderly males.

The greater first-day mortality among offspring of experimental rats (table 2) suggests either feebleness of the young, lack of proper maternal care, or both. That these rats were feeble at birth seems unlikely, since their weights were equal to those of control litters. The instances of neglect on the part of the experimental mothers mentioned above point to relative lack of maternal instinct.

In these experiments the mortality of the young rats between the first and twenty-first day of life was unusually high. This finding is due, in part, to the fact that fifteen of the experimental and ten of the control females of group 1 were bred at a season which was marked by a general decline throughout The Wistar Institute colony in the ability of lactating females to rear their young to weaning age. The poor performance of our own rats at this time is in contrast to earlier results with the remainder of the air-blasted and control females. At weaning, 77.2% of the young of these experimental rats were still alive, and 88.6% of control offspring. However, the probability that this difference was due to chance is only one in fifty. This low probability figure deters us from concluding that under normal cricumstances the depressed maternal behavior of air-blasted rats at parturition extended throughout the suckling period.

We assume that our results were due directly to the disturbing sound of the air-blast. The handling of the animals incidental to the procedure was probably not a contributing factor. Ball ('38) remarked that rough treatment increases sexual receptivity; but with the exception of being lifted in and out of cages, experimental animals received no unusual handling. During the air blasting, many of the rats showed excited activity; some of them exhibited running attacks and convulsions; but Marshall ('42) pointed out that increased exercise does not accelerate gonadal activity, and we have found no other statement in the literature concerning its effect upon mating.

It is generally recognized that certain external stimuli, acting presumably via the hypothalamus and pituitary, may affect reproductive phenomena (Marshall, '42). Much work has been done, especially with birds (Rowan, '38) and rats (Fiske, '41) on the role of light as such a stimulus. That sound might produce the same effect was tested by Browman ('37), who noted an increased irritability in his rats but no change in activity or in vaginal smears. Britt ('41), using an air blast or an auto horn to stimulate rats, found the estrous cycles altered.

The production during air blasting of a generalized autonomic discharge (Farris and Yeakel, '42), resulting in running attacks and convulsions, shows that the auditory stimulus may spread to the hypothalamus, and could conceivably affect both the hypothetical sex center situated in that area (Bard, '40) and the pituitary. It has been shown that hypothalamic lesions depress sexual receptivity in guinea pigs (Brookhart, Dey and Ranson, '41). Perhaps the sound of the air-blast exerts an opposite effect. Whatever the mechanism may be, auditory stimulation appears to affect mating and probably maternal behavior during and after parturition in rats.

SUMMARY

1. Virgin female albino rats, air blasted 5 minutes daily for 5 days a week after weaning, were mated with males of equivalent age similarly treated.

2. Pregnancies in experimental females exceeded controls by 30%. The difference is statistically significant.

3. Litters cast by experimental females contained a normal number of young of normal weight, but first day mortality was 10% greater than in control litters. The difference in survival is statistically significant.

4. Survival of young to 21 days of age was not affected by airblasting of the mother.

5. While the sound of an air blast appears to stimulate sexual receptivity, it seems to depress normal maternal behavior at parturition.

We are indebted to Dr. F. W. Irwin, of the Department of Psychology, University of Pennsylvania, for advice upon statistical analysis; and to Dr. Helen Dean King, of The Wistar Institute, for helpful criticism of the manuscript.

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A CELLOPHANE STRIP METHOD ESPECIALLY ADAPTED FOR THE PREPARATION AND STUDY OF MARCHI-TREATED SERIAL SECTIONS[1]

GRANT LITSTER RASMUSSEN[2]

Department of Anatomy, University of Minnesota, Minneapolis

THREE FIGURES

Several hundred celloidin sections stained by the Marchi technique may be required in studying serially any one of the longer degenerating fiber tracts of the brain and spinal cord. The procedure usually followed in preparing sections of several such pathways is so expensive and tedious that a more practical method was sought for the preparation, study and storage of many series of sections.

The method as finally developed and to be described has the following chief advantages: (1) It saves time by eliminating the laborious procedure involved in the old method of placing serial sections between paper strips or on glass plates and the subsequent dehydrating steps prior to permanent mounting. This is achieved by directly clearing the tissue blocks, following chloroform hardening, in cedarwood oil and mounting the sections as cut in this oil between two strips of cellophane. The apparatus devised and used in the latter connection will be described below. (2) The sections thus cleared and serially mounted can, at once, be quickly and conveniently studied with the aid of a special microscope unit attached to the above mentioned apparatus. Thus, it will be apparent, the latter procedure provides a more direct and rapid means of tracing degenerated fibers than by manipulation of slides.

Conceivably, this method has applicabilities other than Marchi-treated material.

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[1] A portion of a thesis submitted in partial fulfillment of the requirements for the degree of master of arts at University of Minnesota, 1935.

[2] Manuscript prepared at present location: The Department of Anatomy, University of Buffalo.

MATERIALS, METHODS AND CONSTRUCTION OF APPARATUS

Material used for mounting and enveloping sections. The optical qualities of moisture-proof cellophane (300 M.A.T., Dupont)[3] have proved to be satisfactory in studies of Marchi-treated sections since in such studies high magnification is not required. It is probable that an even more suitable cellophane or the like will be available in the near future.

When, in 1932, this method was demonstrated before the American Association of Anatomists, query was made concerning the preservative properties of the cellophane relative to Marchi-stained granules of the inclosed sections. Since the method had not been used long enough to provide a reliable answer, the cellophane-mounted sections then demonstrated have been compared annually with similar sections of equal age which were mounted on glass slides in the usual way. After 12 years the cellophane-inclosed sections show no important signs of deterioration and the appearance of the degenerate myelin of such sections is as good as that of sections mounted in balsam without coverslips. The well preserved osmicated fatty globules and the translucency of the sections indicate that the cellophane and immersion oil used in this method satisfies the desired requirements. Other and cheaper clearing oils have been tried but proved to be too volatile and detrimental to the fatty globules of degenerate myelin. However, the use of the more expensive oil need not be a serious drawback to this method since it can and should be sparingly used. I have recently tried, with promising results, a non-drying immersion oil called "Crown Oil".[4] It is somewhat more costly than cedarwood oil but otherwise seems more suitable for this method.

Construction of the serial-mounting apparatus and its usage (fig. 1). This apparatus may be used in conjunction with either a sliding or rotary microtome as shown in figures 1 and 2, respectively. Certain advantages are gained by using the rotary machine as equpiped with a celloidin-knife holder providing the block sizes come within the excursion limitations (about 1½″) of this type microtome. As shown in figure 2, sections are received by a spatula resting against the knife and are transferred to the mounting platform by depressing the handle connected with the spatula. This obviates the manual transfer of the sections required when using the sliding microtome.

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[3] The moisture-proof cellophane (300 M.A.T.) may be procured in desired widths and lengths at a nominal cost from the Dupont Cellophane Company, Inc., 350 Fifth Avenue. New York, N. Y. The adhesive (no. 446) may also be purchased from the above address.

[4] Crown Oil may be procured from Techni Products Co., P. O. Box 358, Buffalo, N. Y.

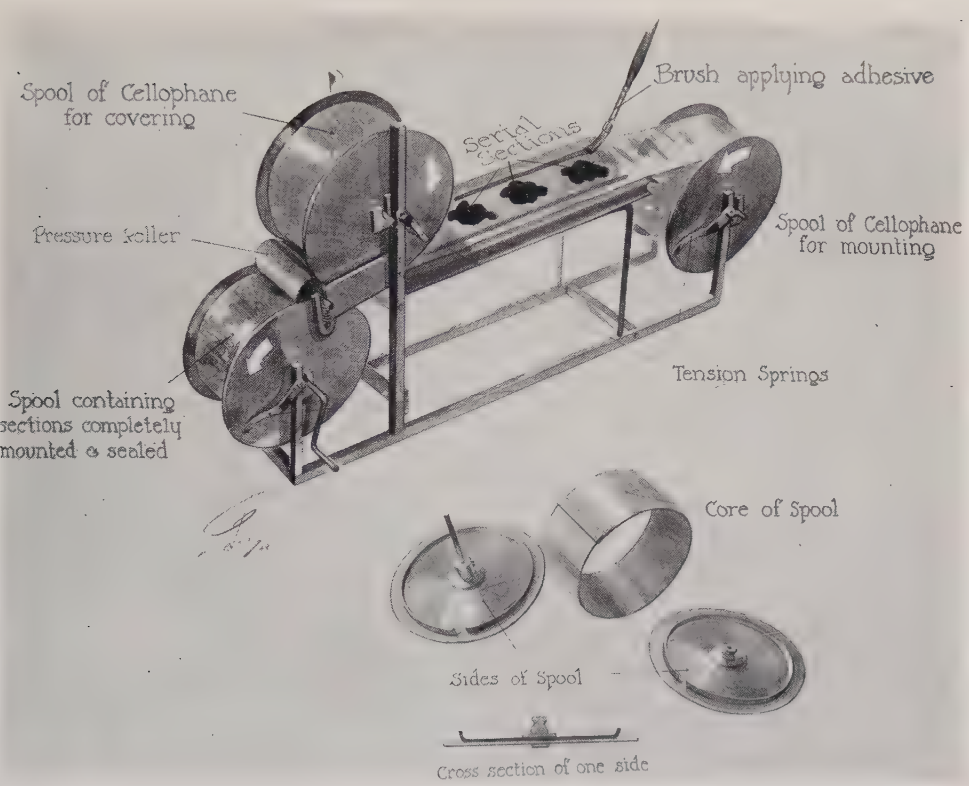
Spool of Cellophane for covering
Brush applying adhesive
Serial Sections
Pressure roller
Spool of Cellophane for mounting
Tension Springs
Spool containing sections completely mounted & sealed
Core of Spool
Sides of Spool
Cross section of one side

Fig. 1 The serial mounting apparatus without the section transfer device. Below is disassembled spool.

The size of the mounting-apparatus is more or less arbitrary. The one here described (fig. 1) handles 2″ cellophane strips and has overall dimensions of 19″ long, 10″ high and $2\frac{3}{4}$″ wide.

The frame bearing the spools is constructed of $\frac{1}{4}$″ square brass rod and that supporting the mounting platform of $\frac{3}{16}$″ round rod. That portion of the framework holding the upper spool, mounting platform and pressure roller is designed to be detachable for the purpose of allowing substitution of the special microscope unit between the lower spools shown in figure 3. The basal frame has dimensions of 13″ × 4″ × $2\frac{3}{4}$″. Precautions should be taken in the construction to make accurate alignment of the spools with each other.

The reels are of the same size but not necessarily of similar construction. Only the spool receiving the sections need be designed for disjunction to allow replacement of a completely mounted series by an empty core. The latter is of light weight tin or zinc 4″ in diameter and the same width as the cellophane strip. Several of these cores are

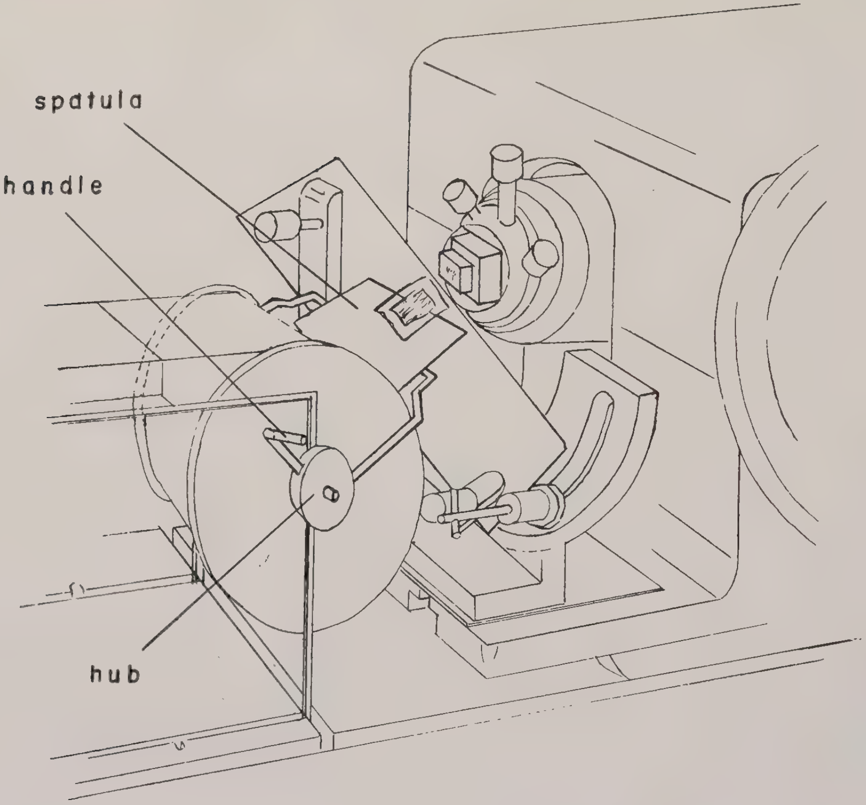

Fig. 2 The section transfer device as used with rotary microtome equipped with celloidin knife holder attachment.

necessary for storage of sections and a tin-smith can make them at a nominal price. The sides of the spools are of ⅟16″ sheet brass and 4⅝″ in diameter. A ¼″ flange made by turning the edge of a copper disc is fitted by solder or rivets to the medial aspect of each side. The flange should fit snugly within the core and a slot should be provided in each flange to accommodate the crimped edges of the core.

The cellophane is held taut by means of friction or tension springs (microscope stage clips used) placed on one side only. The pressure roller serves to squeeze air bubbles from the surface of the sections but this device is optional since this may be accomplished manually through finger pressure. The roller may be of metal or any other hard material.

A coiled spring is attached to each extremity of the roller's axle and the other ends of the springs are fixed to the horizontal frame piece. The springs exert a downward pull on the roller which in turn compresses the strips against the sections. The axle rotates in deep slots permitting the roller to adjust itself to the increasing turns of cellophane.

The section-transfer device. The contrivance (fig. 2) for mechanical conveyance of sections to the mounting platform is a handy time saver. The ease with which the sections slide onto the spatula increases with

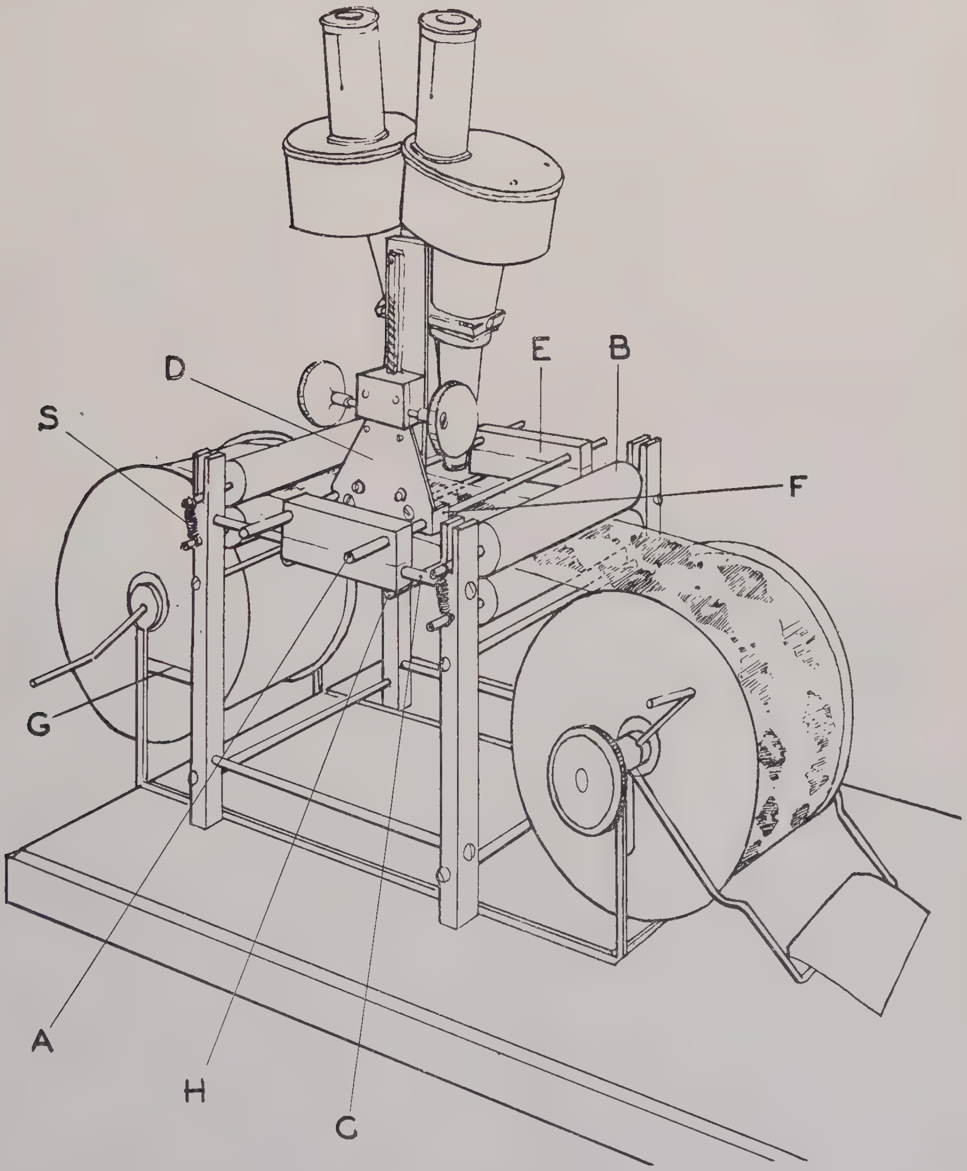

Fig. 3 The microscope unit and its incorporation with part of the mounting apparatus.

the thickness of the sections and rigidity of the celloidin. Marchi preparations are usually cut at 50 μ or more and at this thickness they will pass unaided and unwrinkled upon the metal receptor. The receptibility of the sections is further enhanced by keeping the spatula and knife free of oil with a xylol dampened cloth.

The spatula is a thin metal strip oriented and soldered to a U-shape frame so as (1) to have its upper edge fit flush against the side of the knife and (2) to lie as nearly parallel as possible to the side of the knife in order to facilitate the sliding of the section upon it. The free ends of the U-shape frame insert into hubs which rotate about the axle of the spool. A handle for moving the spatula is fixed to one hub only.

Method of preparing blocks for sectioning. The author favors the Swank and Davenport ('34) technique over other variations of Marchi's method, because of its reliability and clearer background. The latter characteristic permits the study of sections up to 100 μ which is a decided advantage in following the smaller widely scattered fibers.

The brain is cut into 3-mm. slices with a macrotome that insures uniform thickness (Rasmussen, '31). In order to obviate the placement of each slice of tissue on a separate mounting block the following procedure is used which permits continuous cutting of several blocks and in proper sequence. Four or five pieces are assembled in their natural position and a thin glass rod is passed through the group. Then the pieces are space 2–3 mm. apart to facilitate osmification, dehydration and celloidin infiltration. To avoid breaking the fragile rods the solutions are changed carefully by pouring them from the container in which the blocks were first placed. Prior to embedding, the blocks are reassembled to their original apposition and exposed to the air until a rather heavy scum forms about the surface of the tissue. This prevents disarrangement of the blocks while they are gently lowered (greater surface downward) into an imbedding container of thick celloidin. The celloidin is further concentrated in a closed receptacle in which a dish of concentrated sulfuric acid is placed. Finally, the rod is carefully removed when the viscosity of the embedding media alone is sufficient to maintain stability of the blocks. The removal without displacement of the slices or breakage of the rod is executed by pressing downward on the upper block with a curved forked instrument as the rod is withdrawn. The celloidin is then hardened with chloroform first by subjection to its vapor and finally by submersion.

After attaching the embedded tissues to a mounting block they are transferred to cedarwood immersion oil for 12–24 hours. To conserve the rather costly oil only the celloidin bearing the tissue is submerged. Complete penetration of the block is unnecessary for sectioning since a rather superficial coat of oil will prevent drying out of the tissue block provided cutting and mounting is not unduly prolonged. It is important however, that the cut surface of the block be immediately protected with an oil film as each section is cut.

Cutting and mounting the sections. The method is as follows: (1) Excess oil is wiped from block, (2) a thin film of oil is applied to its cut surface, (3) after cutting, the section is transferred to cellophane, oiled surface down, and the other side is then coated sparingly with oil and for a short distance beyond margin of the section. Excess oil tends to be forced out between strips thus causing adjacent layers of cellophane to adhere to each other. The sections are enveloped and sealed with cellophane adhesive (no. 446, Dupont)[5] upon being wound on the receiving spool.

The construction of the microscope unit and its usage (fig. 3). Since the complete series is mounted within a flexible continuous strip it offers a very favorable condition for following degeneration through a large number of sections. Inspection is facilitated by the use of the specially designed microscope unit that allows coverage of sections whose movement is necessarily limited to lateral directions. The unit replaces part of the mounting apparatus and the cellophane strip is fed through it as shown in figure 3. The sections are successively brought under the microscope field by simply revolving the spools one way or the other. Complete coverage of the sections is made possible by means of a movable microscope base which allows horizontal movement.

It has been my practice to make complete observations and notes from sections in this manner. At this time, certain representative sections are marked and later removed and mounted on glass sides for the purposes of reference or demonstration. These are removed by cutting through the cellophane around the sections with scissors in such a way as not to disrupt the continuity of the strip. The covering readily slips off and the sections are mounted in thick balsam or clarite with or without coverslips. The remaining sections may be stored on a spool-core or discarded, depending on their future utility.

The essential parts of the apparatus are a stationary rectangular frame, a movable platform supporting the upper part of a stereoscopic binocular microscope and two pairs of compression rollers. For thick sections, a stereoscopic microscope is preferred because its depth of vision enables one to distinguish the beaded arrangement of transversely cut degenerating fibers from granular artifact and also to recognize the directional course of the fibers.

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[5] See footnote 3.

The microscope support consists of two movable interlinking parts. Lateral movement is gained by excursion of the two brass blocks E (connected and held fast by rods H) on the horizontal rods C. To-and-from movement is made possible by the excursion of the two rods A through holes in blocks E. The microscope is firmly fastened to rods A by means of (1) a brass block (F) connected to (2) plate D to which the microscope is fastened by screws. The plate (D) must necessarily be modified to fit the particular model used.

The compression rollers (B) are for the purpose of holding the cellophane strips horizontally and freeing from the sections any air bubbles that might be present. The rollers are made of brass tubing ($\frac{5}{8}''$ in diameter) provided with circular end plates through which the axles pass. To the extremities of the upper and lower axles are attached coiled springs (S) that provide slight compression.

Illumination is furnished by an ordinary rectangular microscope lamp attached to the under part of the movable stage thus permitting the light to follow the microscope field in lateral directions.

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STUDIES ON THE INGUINAL REGION

I. THE CONJOINED APONEUROSIS VERSUS THE CONJOINED TENDON

SIMON B. CHANDLER AND MELVIN SCHADEWALD
West Virginia University School of Medicine, Morgantown

THREE FIGURES

INTRODUCTION

The lower abdominal wall region is important to the surgeon as well as the morphologist. Recently both anatomists and clinicians have begun to question the conventional description of the arrangement of the musculo-aponeurotic or fascial condition of the region. Zieman ('40) refers to the conjoined tendon as a ''fallacy.'' Anson and McVey ('38) state that it is quite unusual to be able to demonstrate a conjoined tendon and point out several discrepancies in the arrangement of the layers of the inguino-hypogastric region.

MATERIALS AND METHODS

These observations are based on 220 dissections at West Virginia University School of Medicine, University of Pittsburgh, and a few at Columbia, Chicago and Northwestern. In some instances one side of the specimen was not suitable so that there is not an equal number of right and left body halves. These specimens were at least partly dissected by medical students but no observations are herein recorded unless the musculo-aponeurotic layering was adequate to give a reliable concept of the region. The number of females in the series was fifteen.

The internal oblique and transversus muscles. Our observations show sufficient variations from the usual description in most textbooks to justify a word of explanation. The internal oblique muscle arises from almost the whole of the inguinal ligament. The lowermost fibers run parallel or slightly oblique to the ligament. The fascicles arising from the inguinal ligament give origin to the cremasteric muscle fibers in the middle covering of the spermatic cord. This portion unites with its fellow of the opposite side and to the whole ventral surface of the pubic bone. Considerable variation exists in the amount of muscle or aponeurotic tissue in the lower abdominal wall region. The muscle fibers of the layer may begin lateral to the spermatic cord or they may extend to or even overlap the rectus muscle. Whether muscle or aponeurotic tissue is present the general direction is parallel or even oblique to the inguinal ligament. No arching portion of the muscle exists. A falx is prominently featured in most text books but was present in 5.5% of this series. The transversus abdominis seldom arises from the whole of the inguinal ligament. Anson and McVey ('38) report an incidence of 3%. Even when the mucle fascicles of the transversus do not arise from the whole of the inguinal ligament the fibers run either parallel to or oblique to the ligament. No arching occurs to form an opening for the spermatic cord. In no instance does the transversus form a roof for the inguinal canal.

Conjoined aponeurosis. The conjoined tendon as defined by Cunningham's text book of anatomy ('43) is the union of the aponeuroses of those portions of the internal oblique and transversus muscles which arise from the inguinal ligament, insert medially into the linea alba and inferiorly to the pubic crest and pectineal line. This description more nearly defines an "aponeurosis" rather than a "tendon." We suggest the name conjoined aponeurosis for the union of the internal oblique and transversus muscles.

Our observations show that this conjoined aponeurosis (fig. 1) divides just lateral to the rectus muscle into two lamellae. The ventral one passes in front of the rectus as a part of its sheath and inserts into its fellow of the opposite side and inferiorly into the pubic crest and along the pectineal line. The ventral lamella was absent bilaterally in one cadaver in its lowermost portion. The dorsal lamella attaches firmly to the lateral border of the rectus but sends a strong fibrous sheath to cover the whole dorsal surface of the muscle. This lamella attaches firmly below to the lacunar ligament.

The inguinal (Hesselbach) triangle. Anson and McVey ('38) state that the muscle portion of the internal oblique does not have a highly variable medial extent. We oberved marked differences in the amount of muscle and aponeurosis present in the inguinal triangle.

Due to the importance of the inguinal triangle as the location of direct hernia careful measurements were made as to the relative amounts of muscular and aponeurotic tissue in this triangle. The internal oblique was muscular (fig. 2) in the whole of the inguinal triangle in 21% of the 220 body halves; one-half or more in 46% and in 32.8% the muscle portion did not extend into the triangle or only slightly. In the same 220 body halves the transversus abdominis (fig. 3) was entirely muscular in 4.2%; one-half or more in 40.5% and none at all or slightly in 55.3%.

Thus the inguinal triangle is very seldom all aponeurotic or muscular since both layers contribute varying amounts of aponeurosis and muscle to the triangle.

Although the internal oblique muscle arose from the whole of the inguinal ligament the muscle fascicles near the spermatic cord were often thin and scattered. Aponeurotic tissue also gave way to fascia which with a few muscle fibers extended out over the spermatic cord as its middle covering. The transversus abdominis seldom arose from the whole of the inguinal ligament but its union with the internal oblique to form the conjoined aponeurosis fills in the area with aponeurosis or fascia. Text books usually feature a conjoined tendon in this area. When present it is a local thickening in the conjoined aponeurosis. Its fibers curve down in front of the spermatic cord to insert into the ilio-

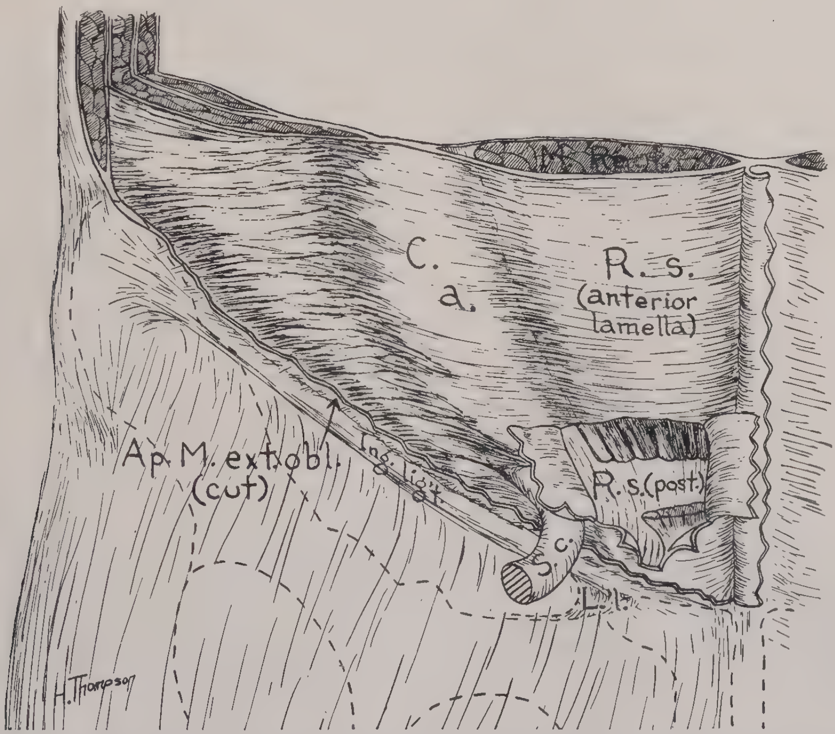

Fig. 1 The structure of the conjoined aponeurosis and its relation to the rectus muscle. The aponeurosis of the external oblique has been removed to show the union of the aponeuroses of the internal oblique and transversus muscles. This conjoined aponeurosis divides into two lamellae to inclose the rectus. C. s. conjoined aponeurosis; R. s. anterior lamella and R. s. (post.) the posterior lamella of the rectus sheath; S. c. spermatic cord; L. l. lacunar ligament; Ing. Lig't. inguinal ligament.

pectineal line. Such a structure was present 13 times in 220 body halves. The very frequent absence of a conjoined tendon shows how unimportant it is as a barricade against hernia.

The inguinal triangle was also studied against a background of bright light. The region seldom has the same thickness at all points. The aponeurotic tissue may end suddenly or gradually be replaced by fascia. There may be small areas much thinner than others. Sometimes these local areas may be more fatty than others and at other times they appear as thinned out fascia. In any case they are probably potential sites for direct hernia.

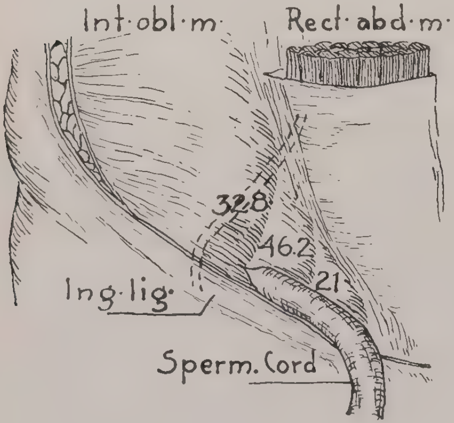

Figure 2

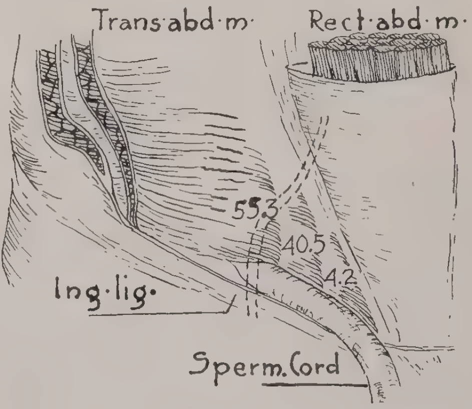

Figure 3

Fig. 2 The medial extent of the internal oblique as muscle into the inguinal (Hesselbach) triangle. In 21% of 220 body halves this muscle extends through the whole of the triangle and in some instances overlapped the rectus. About one-half of the triangle was muscular in 46.2% and only slightly or not at all in 32.8%. Deep inferior epigastric artery is shown by dotted lines.

Fig. 3 The medial extent of the transversus abdominis as muscle into the inguinal (Hasselbach) triangle. In 4.2% of 220 body halves this muscle extended through the whole triangle and occasionally overlapped the rectus. About one-half of the triangle was muscular in 40.5% and only slightly or not at all in 55.3%. Deep inferior epigastric artery is shown by dotted lines.

SUMMARY

Observations on the inguino-hypogastric region in 220 body halves show:

1. The internal oblique muscle arises from almost the entire inguinal ligament. Its lowermost fibers run parallel or even oblique to the ligament.

2. The transversus abdominis seldom arises from the whole of the inguinal ligament but its fibers also run parallel or oblique to the liga-

ment. The inferior edge of the muscle seldom forms an arch nor is it the roof of the inguinal canal.

3. The internal oblique and transversus unite to form a conjoined aponeurosis. The relation of these muscles and their aponeurosis to the inguinal triangle is briefly discussed.

4. The lowermost portion of the inguinal triangle has weak thinned-out areas which may be the origin of a direct hernia.

5. A conjoined tendon was observed in slightly over 5% of 220 body halves.

ACKNOWLEDGMENT

We are indebted to Mr. Harvey Thompson who made the drawings.

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DUPLICITAS ANTERIOR IN THE TOAD, ELEUTHERODACTYLUS ALTICOLA

W. GARDNER LYNN
Department of Biology, The Catholic University of America, Washington, D. C.

TWO TEXT FIGURES AND TWO PLATES (FOURTEEN FIGURES)

The infrequent occurrence of spontaneous twinning in amphibians has been remarked by many investigators and has been most recently emphasized by Schwind ('42) who has pointed out that, although double monsters are not uncommon among teleosts, reptiles, birds and mammals there have been very few reports of such anomalies among amphibians. The scarcity of such reports is the more significant when one considers the large numbers of frog and salamander eggs which are examined each year in biology class-rooms and laboratories all over the world. Lebedinsky ('23), in describing a case of duplicitas anterior in Rana fusca, states that there had been only four records of spontaneously occurring conjoined twins in Anura prior to his paper. This is in error however, for one of the records which Lebedinsky cites is really a report on twelve cases of such twinning. The present author's rather brief scrutiny of the early literature has yielded seventeen accounts of double monsters in frogs and toads. Of these, twelve were found in Rana esculenta (Born, 1882), four in Rana fusca (Born, 1881; Loyez, 1897; Spemann and Falkenberg, '19; Lebedinsky, '23) and one in the Obstetrical Toad, Alytes obstetricans (Héron-Royer, 1884). In his recent paper, Schwind ('42) has described twenty-nine cases of spontaneous anterior reduplication in Rana sylvatica. Twenty-seven of these were found in a single bunch of eggs. It is noteworthy that all of the cases thus far reported concern embryos or early larvae, so that there are no records of conjoined twins in metamorphosed frogs or toads. The case to be recorded in the present paper is unique in that, although it concerns embryonic stages, the species involved is one which possesses no aquatic tadpole stage and the double monster to be described has, therefore, the body form and internal organization of an adult frog.

The genus Eleutherodactylus is a group of leptodactylid toads which is widespread in tropical America and the West Indies. The embryology of one member of this genus has been described in some detail

(Lynn, '42) and that account will serve as a basis for discussion of the double monster. The large-yolked, unpigmented eggs of these animals are laid on land, in hollows beneath stones or logs. From these eggs, after a period of development which lasts approximately 4 weeks, tiny frogs having the typical adult body form are hatched. During the embryonic history neither external nor internal gills are ever formed, there is no true operculum and the fore and hind limbs appear simultaneously and grow steadily. There are no tadpole-like mouth parts or ventral suckers and the development of such structures as the skull, aortic arches and digestive tract are greatly modified in relation to this direct development. The embryo has a broad, vascular tail which apparently serves as the chief respiratory organ during intra-oval existence. After hatching the lungs become functional and the tail quickly dwindles away.

The specimen under consideration was collected in Jamaica, B. W. I. during the summer of 1941 in the course of an investigation concerning the results of experimental removal of the pituitary anlage in the Eleutherodactylus embryo.[1] The species E. alticola is a Jamaican endemic and, as its name indicates, it is a montane form occurring from about 5,500 feet to the top of the highest mountain in the island, Blue Mountain Peak, at 7,360 feet. The clump of eggs to which the double monster belonged was taken from beneath a stone on the southwestern slope of Blue Mountain Peak on July 15, 1941. There were twenty eggs in the clutch. When the eggs were first examined under the microscope upon arrival at the laboratory 2 days later, it was found that the embryos were in an early limb bud stage (stage –22 as defined by Lynn, '42). Eighteen of the embryos seemed normal and were later utilized for experimental work, one embryo was abnormal in that the body was unusually short and thick, the other was the double monster herein described.

DESCRIPTION OF SPECIMEN

Sketches of the embryo were made when it was first discovered and these are reproduced in figures 1 and 2. Figure 3 shows a photograph made on the following day.[2] It will be noted that, when these illustrations were made, the animal was entirely unpigmented. There were two heads joined just behind the level of the fore limbs. Both fore and hind limbs were clearly visible as rounded buds and a similar, but somewhat larger, bud lying between the two heads apparently represented a fusion of the adjacent fore limbs of the two twins. At this time there was a difference in the size of the two heads, that of the left embryo being the smaller, but this difference gradually disappeared at later stages.

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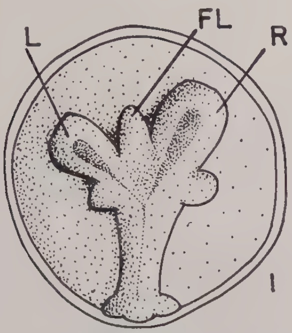
[1] The opportunity to work in Jamaica was afforded by a grant from the Brooks Fund of The Johns Hopkins University. The author is indebted to Mr. C. Bernard Lewis, Curator of the Museum of the Institute of Jamaica, and to the Natural History Society of Jamaica for the use of the Clydesdale House as laboratory and living quarters for our party. Gratitude is also due to Dr. John P. Marbarger who, under difficult conditions, made photographs of the living animal in our field laboratory; to Mr. John Spurbeck of The Johns Hopkins University, who photographed the animal after preservation; and to Rev. Henry E. Wachowski who, at The Catholic University of America, prepared the specimen for microscopic study.



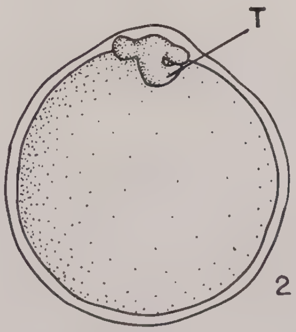


Fig. 1 Dorsal view of the double monster when first discovered. July 17, 1941. FL, fused fore-limbs of the two anterior ends. L, left head. R, right head.

Fig. 2 Ventral view, T, tail.

Observations were made and photographs were taken daily until August 5th, when our stay in the island ended and it was necessary to preserve the specimen. From the series of photographs, six have been chosen for illustration (figs. 3–8). By July 19th (fig. 4) an intense aggregation of pigment cells had appeared along the adjacent sides of the two embryos while the outer sides had only a few isolated melanophores. The photographs show the gradual increase in pigmentation and its spread down over the yolk (the future ventral body wall). It can be seen that the dark streak between the two adjacent spinal cords persisted through all the embryonic stages observed. This streak is of course, to be explained by the fact that the melanophores derived from the neural crest material of the two adjacent sides could not migrate down to furnish the pigmentation of one whole side of the body as they would have done in a normal embryo, but were instead densely packed in a very limited area of skin. Although this deeply pigmented area cannot be distinguished in the photograph of the specimen after preservation (fig. 9), the sections show the piling up of melanophores in this area very clearly (fig. 15, M).

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[2] All of the photographs of the living animal leave much to be desired. They were taken by the light of a gasoline lantern with a small camera mounted on a compound microscope. Since these embryos continually carry out a slow counter-clockwise rotation within the egg-membranes it was not possible to give as long exposures as the available light required. It was necessary to sacrifice depth of focus, and even with the lens wide open the negatives were somewhat underexposed.

Comparison of the photographs shows that the fused forelimbs, which are clearly seen in figure 4, gradually disappeared during later development; for, as the two heads enlarged. they became fused further and further anteriorly and the intervening limb tissue appears to have atrophied. At the time of preservation a small external flap was still present in this region (fig. 10) but the sections show no skeletal parts in this structure. The two adjacent scapulae are present, however, and are fused at their ventral ends with each other and with the anterior end of the basihyoid cartilage.

During the latter part of the time that the embryo was under observation it was noted that the hind-limbs, although they had differentiated fully, were abnormally small and were somewhat distorted. This can be seen in figures 9 and 10 which show the embryo after it had been removed from the egg membranes and preserved. The sac-like, highly vascular tail is shown in these photographs and the horny egg-tooth can be seen at the tip of the upper jaw of each head. On the basis of its general development at this time one may judge that the animal would have reached the hatching stage in about 5 days.

The internal anatomy was studied by means of serial sections some of which are illustrated in figures 11 to 16. At the time of preservation (figs. 9 and 10) the two heads diverged so widely that their antero-posterior axes were almost directly opposed. In the sections, therefore, the heads are cut nearly longitudinally although the body is sectioned transversely.

Study of the sections reveals that there are two complete brains and four complete internal ears. The two spinal cords join dorsally at the level of the second spinal nerve and their lumina unite at the level of the fourth spinal nerve. No spinal nerves are present on the adjacent sides of the two cords and this is reflected in the pycnotic condition of the cells of the adjacent portions of the paired spinal cords (fig. 14). The indication is that these cells had differentiated but had later degenerated. As Schwind has noted in his cases, the two spinal cords unite by first tilting towards each other dorsally, so that the roof plates fuse. More posteriorly this tilting continues so that the dorso-ventral axes of the two cords diverge ventrally and when fusion of the lumina has occurred, the single tubular structure so formed really has a floor plate made up of the medial sides of the originally separate cords (figs. 14 and 15).

It has frequently been noted that in double monsters of this type, the doubling of the notochord is more extensive than that of any other structure. In the present specimen the two notochords do not fuse at all. They are rather widely separated at most levels of the body (figs. 14 and 15) but approach each other near the root of the tail. Here the right notochord decreases in diameter (fig. 16) and, although both continue into the tail, the right soon dwindles away and only the left notochord continues to the tip of the tail.

Fusion of the two digestive tracts occurs at the posterior end of the oesophagus so that there is a single stomach. There are two livers and two gall bladders however, and the liver of the left twin is reversed in situs, having its gall bladder on its left side instead of on its right. Two tracheae and two pairs of lungs are present. Because of the wide divergence of the two heads and the relatively early stage of development of the lungs, the two respiratory tracts do not approach each other near enough to show any fusion.

In the body region, only the lateral mesonephroi are present. A curious feature of the internal anatomy however, is an unpaired mass of cystic mesonephric tissue lying between the two heads, dorsal to the heart and enclosed by the two adjacent scapulae (fig. 11). This mass is interpreted as representing the two adjacent mesonephroi which, after differentiating, lost connection with the body cavity during the growth and further fusion of the twin anterior ends. The cystic condition of the structure is explained by the fact that it has no duct.

The pronephroi have normally degenerated to glandular-appearing masses at this stage. In this specimen such a picture is presented by the pronephros of the right side, but that on the left side is enlarged and cystic (fig. 14, P).

Study of the heart region reveals a normal heart on the left side and a much modified one on the right. Two postcaval veins emerge from the two livers and each enters a separate sinus venosus. On the left side the sinus venosus enters an atrium which is well differentiated and possesses the beginning of an interatrial septum on its left side. This in turn enters a muscular ventricle and from the right side of the ventricle the conus arteriosus emerges and gives off three pairs of aortic arches. The left heart is therefore normal in development and in situs. On the right side the sinus venosus enters a thin-walled chamber which doubtless represents the atrium of the right heart but is small and without a septum. Shortly anterior to this a small muscular structure on the ventral wall of this atrium represents the ventricle and conus, but its cavity is completely occluded. The atrium then sends a large connective across to the sinus venosus of the left heart and it is clear that the blood from the right side was thus sent into the left heart for, although the atrium of the right twin continues for some distance anterior to this point, it finally ends blindly. The blood supply to both heads is derived from branches of the conus of the left heart. It is not unlikely that, at early stages, both hearts were well developed and that the reduced condition of the right heart at the stage studied is a result of degenerative changes. Schwind ('42) reports a case in which two separate hearts could be seen at early stages, but had fused by the time the specimen was preserved.

Unfortunately, in the present specimen, the heart region was not visible in life because of the curvature of the animal around the yolk.

DISCUSSION

Since spontaneous twinning seems to occur with greater frequency in large-yolked eggs like those of teleosts, reptiles and birds than it does in smaller-yolked forms, it might be supposed that such twinning may prove to be common in the group of amphibians which the present report concerns; for the eggs of Eleutherodactylus are much larger than those of ordinary amphibians and are indeed larger than many teleost eggs. The lack of any previous records of twinning in this group could easily be attributed to the infrequency of observations on eggs of this type. Although a considerable number of amphibians is known to have large-yolked eggs and direct development, most of them are found in the tropics and the eggs have been seen by relatively few collectors. The present author finds, upon examining his field records, that he has observed some 4,500 eggs of the genus Eleutherodactylus in the past 12 years without finding any other cases of twinning but this is really a very small number, equivalent to what would be seen in a single large bunch of Rana pipiens eggs.

Twinning has been induced in Fundulus eggs by exposure to ultraviolet light (Hinrichs and Genther, '31) but Schwind's attempts to cause twinning in the eggs of Rana by this and other treatments, were unsuccessful. In view of its large size and unusual mode of development, similar experiments with the egg of Eleutherodactylus would be of great interest.

SUMMARY

1. A case of duplicitas anterior in an embryo of Eleutherodactylus alticola, a leptodactylid toad having large-yolked terrestrial eggs, is

reported. The monster was discovered in an early limb-bud stage and was observed until near the end of its period of intra-oval development, at which time it had nearly attained the body form of the adult toad.

2. The internal morphology is described from serial sections. The two spinal cords join at the level of the fourth spinal nerve but the two notochords remain separate throughout their extent. Two livers are present, that of the left twin being in reversed situs. The heart of the left twin is normal but that of the right twin is reduced to a tube connecting with the sinus venosus of the left heart.

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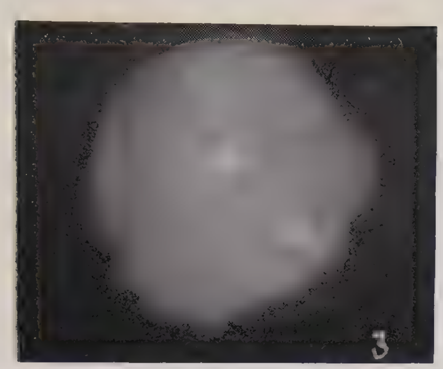
PLATE 1

EXPLANATION OF FIGURES

Figs. 3–10 Photographs of the specimen at successive stages of development.

3 July 18. × 10.
4 July 19. × 14.
5 July 23. × 8.
6 July 27. × 8.
7 July 28. × 8.
8 July 30. × 7.
9 After preservation, August 5. Dorsal view. × 5.
10 After preservation, August 5. Ventral view. × 5.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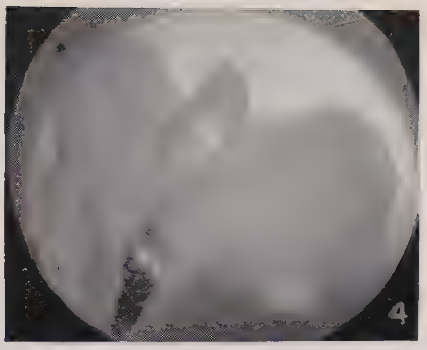
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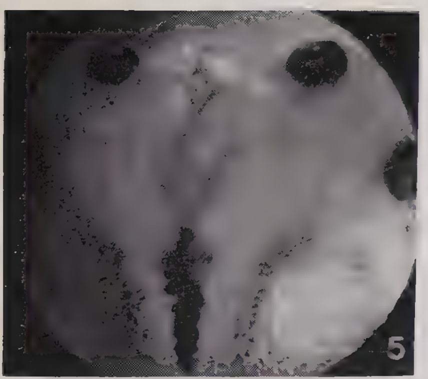
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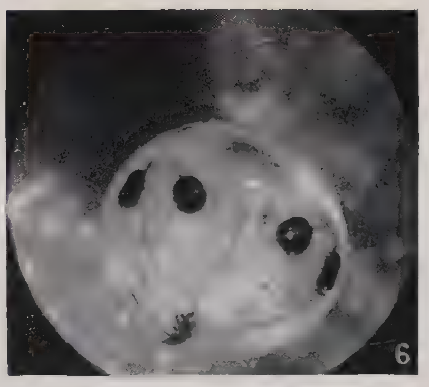
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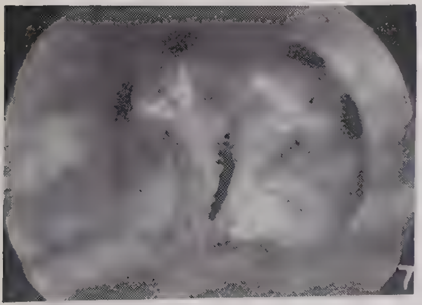
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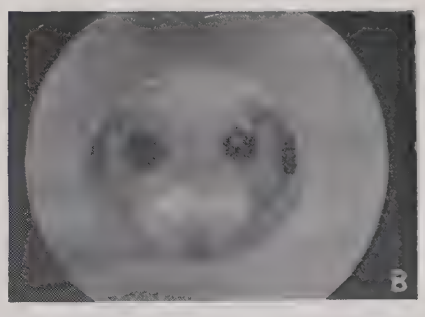
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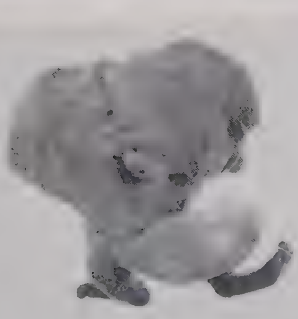
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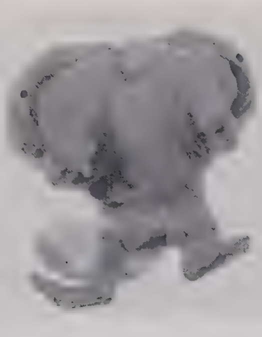
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PLATE 2

EXPLANATION OF FIGURES

Figs. 11–16 Photographs of sections of the double monster at different levels. × 30.

11 Section at the level of the two adjacent otic capsules to show unpaired median mass of cystic mesonephric tissue.

12 Section at the level of the upper end of heart. The left heart is on the reader's left; the right heart, represented by a relatively undifferentiated tube, is on the reader's right.

13 Section at the level of the lower end of the heart at the point where the postcaval vein leaves the left liver.

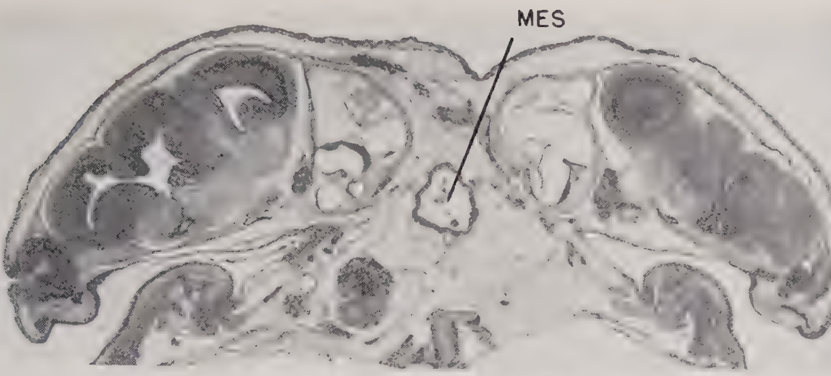
14 Section at the level where the two spinal cords come into contact.

15 Section at the level of fusion of the lumina of the two spinal cords.

16 Section through the base of the tail showing the spinal cord and the left notochord cut twice. The right notochord is sectioned at the base of the tail but does not extend to the tip of the tail.

ABBREVIATIONS

ATR, atrium; C, connecting vessel between right and left hearts; CA, conus arteriosus; LL, left liver; LN, left notochord; M, melanophores, densely aggregated; MES, fused mass of mesonephric tissue; P, cystic pronephros; RH, right heart; RL, right liver; RN, right notochord; SC, spinal cord; SV, sinus venosus; V, ventricle.



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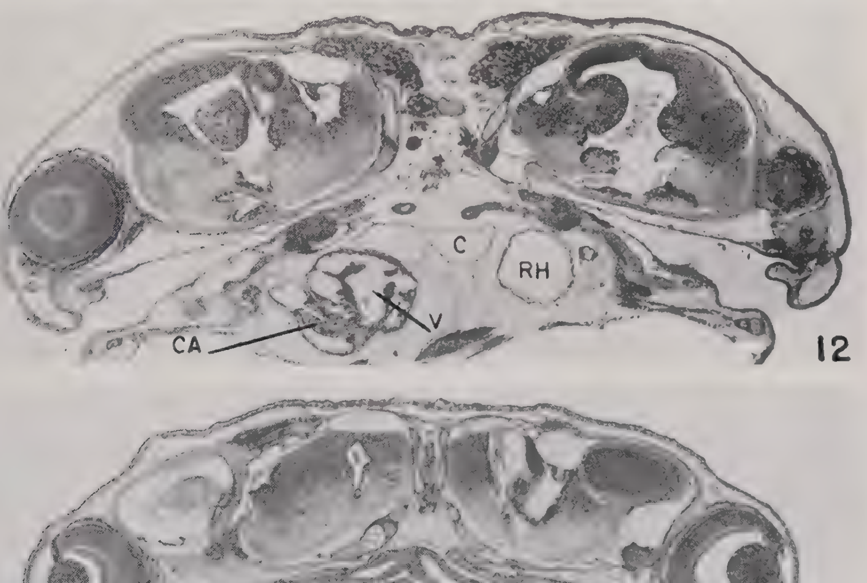

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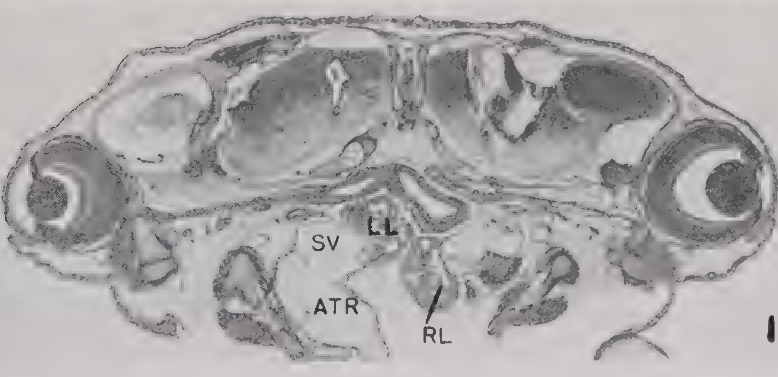

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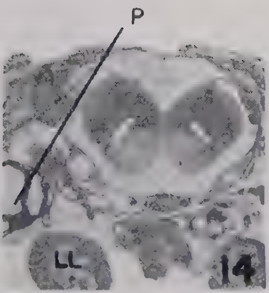

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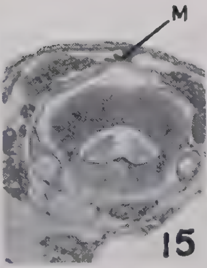

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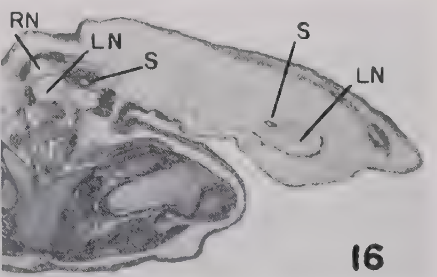

16

TOOTH REPLACEMENT IN BREWER'S MOLE

W. ROBERT EADIE
Department of Zoology, Cornell University, Ithaca, New York

ONE PLATE (FOUR FIGURES)

INTRODUCTION

Tooth succession among the insectivores has been described by several workers, notable Leche (1895) and Woodward (1896), and has been summarized by Weber ('27). Among the moles, tooth succession has been studied in Talpa, Scalopus, Condylura and Urotrichus, but similar information for the genus Parascalops is not on record. The acquisition of suitable stages makes possible the presentation of the following information on tooth replacement in this genus of moles.

ADULT AND JUVENILE CONDITIONS

Adult moles of this species (Parascalops breweri Bachman) have the hypothetically complete dental formula of placental mammals: i. $\frac{3}{3}$; c. $\frac{1}{1}$; pm. $\frac{4}{4}$; m. $\frac{3}{3}$; total 44. This may be varied occasionally by the presence of an extra tooth (Eadie, '39) while one specimen was collected which had two extra teeth or a total of forty-six. These additional teeth may be in the incisor or premolar series of either jaw and are unicuspids nearly or quite as large as the regular members of the series.

In juvenile moles (8–10 weeks old) that had but recently deserted their home nest the permanent teeth were not fully erupted and some of the temporary teeth were still in place and visible in the jaws beside the permanent teeth. The temporary teeth at this stage are held in place by the gum membranes only and are lost in well cleaned skulls. These teeth are very small (fig. 1) and it is doubtful that they are ever functional. Their penetration of the gums is of interest since in some genera of moles (Scalopus and Condylura) the milk teeth never cut the gums, while in Talpa they barely break through (Leche, 1895).

CONDITIONS IN NESTLING MOLES

In nestling moles approximately 5 days old (70 mm. total length) there are no teeth visible on the jaw surfaces. Serial sections of these jaws reveal the development of both the temporary and permanent dentitions.

The deciduous upper incisors appear as well calcified teeth with the tooth germs of the permanent incisors lying lingual to them. These deciduous incisors are small cone-shaped teeth of which the first is the largest measuring slightly more than 1 mm. in length while the second and third are less than 1 mm. long. The tooth germs of the permanent upper incisors are well developed at this stage although there is yet no evidence of the deposition of enamel or dentine (fig. 2). In correlation with adult proportions the primordium of the first incisor is much larger than that of the second or third.

The condition of the deciduous lower incisors and of the primordia of their permanent successors is much as described for the upper jaw although here there is no appreciable difference in size between the members of either the deciduous or permanent set at this stage.

The temporary canines of both jaws resemble closely the second and third temporary incisors in form and size, while the primordia of the permanent canines are in a stage of development comparable to that of the permanent incisors.

In both jaws the first premolar of the milk set is a large tooth not nearly as far advanced in development as the other members of this set, although enamel and dentine are being deposited. This tooth is in a stage of development comparable to that of the molars described below. On the lingual side of each of these first premolars can be seen a strand of epithelial cells representing the tooth germ for the permanent premolar which has undergone apparent degeneration (fig. 3). Thus it appears that the first premolar of the adult is a persisting member of the milk set and is not replaced. This condition of the first premolar parallels that of Talpa europaea (Woodward, 1896) among the insectivores.

The second and third deciduous premolars of both jaws and the fourth in the lower jaw resemble the temporary incisors and canines in form and size and are small, simple, cone-like teeth. Medial to each lies the well developed primordium of a permanent tooth which is at the same stage of development as the primordia of the permanent incisors and canines. The deciduous fourth premolar of the upper jaw is larger and more complex than the preceding milk teeth but is in a comparable stage of development. It has three roots and a ridge-like cusp. On its lingual side is located the well formed primordium of the permanent tooth.

The molar teeth are at an advanced stage of development with well-formed crowns in which enamel and dentine are present (fig. 4).

DISCUSSION

After examining the available evidence on the milk dentition of the Insectivora, Woodward (1896) concluded that in this order of mammals there is a distinct tendency toward reduction in the functional importance of the milk dentition, and that ''the living Insectivora are specialized forms tending towards a Monophyodont condition in which the preponderating dentition is the replacing or permanent set''.

The condition in Parascalops where, with the exception of the persisting first milk premolars, the members of the deciduous series are minute, spicule-like teeth which are soon lost is additional evidence in support of this conclusion.

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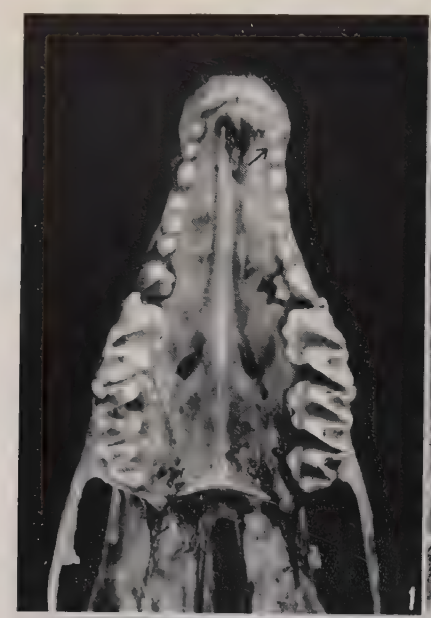

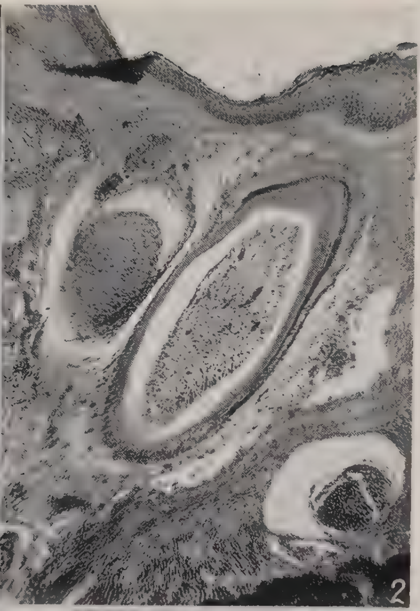

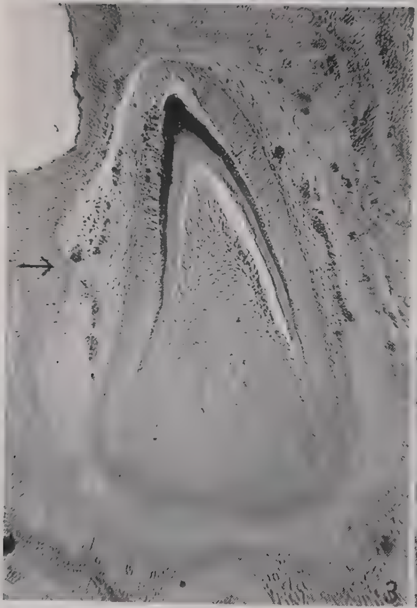

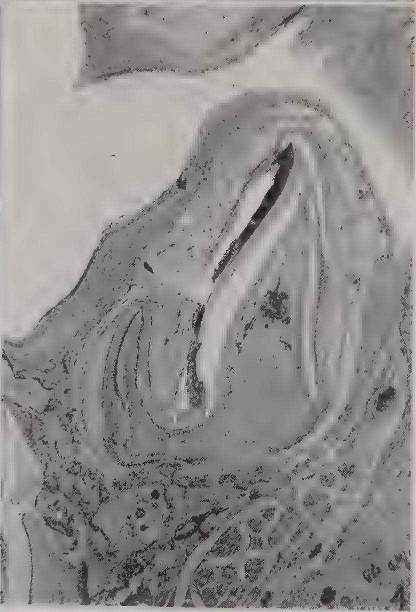

1 View of partially erupted permanent teeth of the upper jaw in a juvenile mole showing a temporary incisor still in place between second and third permanent incisors (arrow). × 4.

2 Section of the upper jaw of a nestling mole. Shows well developed second temporary incisor and the enamel organ of its permanent successor lying lingual to it. × 60.

3 Section of the upper jaw of a nestling mole. Shows first premolar of the milk set in a stage of development comparable to that of the molars. Note the degenerate primordium of the first premolar of the permanent set on the lingual side of this tooth (arrow). × 90.

4 First upper molar of nestling mole showing stage of development comparable to first milk premolar. × 30.

PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

1944

Again, as in 1943, the Executive Committee voted (5 to 4) to omit the regular 1944 meeting, because of the urgent request from the Office of Defense Transportation that civilian travel be severely restricted. It was also again decided to continue all feasible Association activities — including the publication of ''Abstracts'' and ''Proceedings''; nomination and ''provisional'' acceptance of new members; and holding of local or sectional meetings.

Results of mail vote of July 1943. In order to regularize, as far as possible in the absence of an annual meeting, the various activities of the Executive Committee in keeping the Association in operation, and particularly the steps taken by the Executive Committee following the untimely deaths of President Edgar Allen and Secretary-Treasurer Francis H. Swett, a ballot was sent to each member of the Association in July 1943, which contained the following five topics on which a ''yes'' or ''no'' vote was requested:

1. Endorsement of action of Executive Committee in continuing in office all elected officers and representatives now serving, until the next general meeting of the Association.
2. Endorsement of Prof. J. P. Schaeffer (elected First Vice-President) to serve as Acting President until the next meeting, in the place of Prof. Edgar Allen deceased.
3. Endorsement of the appointment by the Executive Committee of Prof. Eliot R. Clark to serve as Secretary-Treasurer until the next meeting, in the place of Prof. F. H. Swett deceased.

4. Endorsement of all actions taken by the Executive Committee as a result of the omission of the 1943 regular annual meeting.
5. Empowering the Executive Committee to take whatever actions may be necessary in the ''interim'' before the next regular meeting.

Of 437 replies that were received, the vote on topics 1–3 was 436 yes, 1 no (one member objected to possibly unduly long terms of office). On topic 4 the vote was 430 yes, 7 no. (The ''no'' votes were mainly due to an unwillingness to ''endorse'' actions the exact details of which were unknown. The Secretary wishes to explain that the ballot was timed to reach the members shortly after their receipt of the 1943 ''Proceedings,'' in which virtually all actions taken by the Executive Committee were published, but the printing and mailing of the ''Proceedings'' were unexpectedly delayed.) On topic 5 the vote was 433 yes, 4 no. (Those voting ''no'' hesitated to give blanket authority to any committee. The members of the Association may be assured that the Executive Committee will consider itself authorized to take only ''necessary'' or routine actions. If any important non-routine matters come up, the entire membership of the Association will be canvassed.)

As a result of this mail vote, the status of the officers, and the actions taken by the Executive Committee in the various emergency situations not covered by the Constitution, have been legalized as completely as is possible in the absence of a regular meeting of the Association.

Reports on finances, membership, etc. In April 1944 the Secretary-Treasurer sent a report to the members of the Executive Committee with a request for a vote on nine of the following items. Most of these are matters customarily acted upon at the annual business session of the Association, following action by the Executive Committee. They have been endorsed, as indicated, by the Executive Committee. The new members, as specified last year, will be rated as ''provisional members'' until voted upon at the next regular meeting of the Association.

1. (a) *Financial statement for the year 1943*

Balance on hand in checking account Dec. 31, 1942 in Citizens National Bank, Durham, N. C. (last audit of acounts)		$1,727.06	
Bank balance received by Acting Treasurer and deposited in First National Bank, Philadelphia, Pa.		1,695.12	
Receipts from dues		1,020.10	
Total credits			$4,442.28
Expenditures			
Postage, stationery, supplies and miscellaneous		137.87	
Wistar Institute			
Abstracts and postage		407.82	
Proceedings and postage		243.40	
Printing		27.00	
First National Bank			
Check returned		2.00	
Charge for handling account		1.04	
Charge for handling account		6.80	
Charge for handling account		4.65	
Citizens National Bank			
Transfer of funds		1,500.00	
Transfer of balance of funds		195.12	
Total expenditures			$2,525.70
			$1,916.58
Assets			
Balance on hand Dec. 31, 1943, and deposited in the name of the American Association of Anatomists in the First National Bank, Philadelphia, Pa.		$1,916.58	
War Bond Defense Series F dated May, 1942 in safe deposit box, First National Bank, Philadelphia, Pa.	$740.00		
Increase in value of War Bond, 1½ yrs.	10.00	750.00	
Total assets			$2,666.58

Total assets increased by $199.52 during the year, resulting from increases of $189.52 in the general account and $10.00 in the value of the war bond.

Endorsed by the Executive Committee "providing the Auditors' Report is favorable."

1. (b) Acting President Schaeffer appointed an Auditing Committee consisting of W. H. F. Addison, Chairman, and E. J. Farris, who submitted the following report:

May 19, 1944

The undersigned Auditing Committee has examined the accounts of the Secretary-Treasurer for the year 1943 and has found total receipts reported to be those entered in the journal, expenditures in accordance with receipted bills and the balance on hand Dec. 31, 1943, in agreement with the bank statement of that date.

The Committee further records the statement of the Secretary-Treasurer, that the War Defense Bond, Series F, M226397F, (original cost $740.00) purchased May 26, 1942, registered in the name of the ''American Association of Anatomists'', is in the care of the Sec.-Treas., deposited in a safe-deposit box in the name of Eliot R. Clark, in the First National Bank of Philadelphia, Centennial Branch, 32nd and Market Sts., Philadelphia, Pa.

Signed:
W. H. F. Addison
E. J. Farris

2. The suggestion that 1944 dues be set at $1.50. This permits distribution of ''Abstracts'' and ''Proceedings'' to all members, and takes care of the growing list of non-paying members (32 elder members, 27 members in various warring countries in Europe and Asia, and 45 in the Armed Services).

Adopted by the Executive Committee.

Membership:

3. The addition of one name to the list of members relieved of the payment of dues. Adopted by the Executive Committee.

4. The resignation of Laura J. Nahm.

5. The suggestion that the regulation that members be dropped for two years' non-payment of dues be relaxed for the duration. This was proposed because of the difficulty of obtaining the present addresses of several members, leaving an uncertainty whether or not they were in the Armed Services and hence exempt from payment of dues. This was approved by the Executive Committee by a vote of 10–1.

6. The Association has suffered great loss during the past year, thru the death of the following two members:

Arthur Dean Bevan, born August 6, 1861, died June 10, 1943. Elected to membership in 1891. Professor of Surgery, The University of Chicago. Formerly Professor of Anatomy: one year at Oregon State University and

12 years (1887–1899) at Rush Medical College. A member of the Executive Committee 1896 to 1898. One of the foremost surgeons of the United States.

Aleš Hrdlička, born in Humpolec, Bohemia, March 29, 1869, died September 5, 1943. Elected to membership in 1898. Curator, Division of Physical Anthropology, United States National Museum, Smithsonian Institution, Washington, D. C. An internationally famous physical anthropologist; founder, and Editor for 24 years, of the American Journal of Physical Anthropology; organizer of the American Association of Physical Anthropologists; author of many books, numerous original contributions and an enormous number of abstracts and critical reviews.

7. The following 33 nominations were endorsed by the Executive Committee. Following last year's ruling, they will be considered *"provisional members"* until finally acted upon by the Association members at the next general meeting. The names in parentheses indicate the sponsors:

Algire, Glenn Horner, M.D., Asst. Surgeon (R), U. S. P. H. S., National Cancer Institute (W. R. Earle, A. J. Dalton).

Angel, John Lawrence, A.B., Ph.D., Assoc. Anat. and Phys. Anthrop., Jefferson (J. P. Schaeffer, G. A. Bennett).

Bassett, David Lee, A.B., M.D., Instr. Anat., Stanford (H. Kirkman, C. H. Danforth).

Berry, Charles M., A.B., M.S., Ph.D. Instr. Anat., Cornell (J. C. Hinsey, C. O. Warren).

Brown, James O., B.S., M.S., Ph.D., Instr. Anat., Pennsylvania (E. R. Clark, R. G. Williams).

Bueker, Elmer D., B.S., M.A., Ph.D., Instr. Anat., Med. Coll. of State of S. Car. (A. M. Lassek, O. H. Kampmeier).

Bullock, Theodore Holmes, B.A., Ph.D., Inst. Neuro-anat., Yale (H. S. Burr, R. G. Meader).

Dougherty, Thomas F., Ph.D., Res. Asst. (rank of Instr.), Yale (L. S. Stone, W. U. Gardner).

Drager, Glenn A., B.S., M.S., Ph.D., Inst. Anat., Texas (Galveston) (R. F. Blount, J. G. Sinclair).

Duke, Kenneth L., A.B., Ph.D., Assoc. Anat., Duke (J. E. Markee, W. H. Hollinshead).

Elftman, Alice Gooding, A.B., A.M., Ph.D., Instr. Biol. Sci., Hunter Coll. (B. L. Maclean, T. N. Salmon).

Evans, F. Gaynor, B.A., M.A., Ph.D., Asst. Prof. Anat., Maryland (E. Uhlenhuth, F. H. J. Figge).

Everett, Newton B., B.S., M.S., Ph.D., Instr. Anat., Mich. (B. M. Patten, R. E. McCotter).

Goldsmith, Eli D., M.S., Ph.D., Instr., C. C. N. Y. and N. Y. Univ. (H. A. Charipper, F. Gudernatsch).

Kaylor, Cornelius T., A.B., M.S., Ph.D., Asst. Prof. Anat., Syracuse (B. P. Armstrong, C. L. Yntema).

Kramer, Theodore C., B.S., M.A., Ph.D., Instr. Anat., Mich. (B. M. Patten, R. E. McCotter).

Lazarow, Arnold, M.D., Ph.D., Senior Instr. Anat., West. Res. (N. L. Hoerr, W. W. Greulich).

Nigrelli, Ross F., B.S., M.S., Ph.D., Pathologist, N. Y. Aquarium, (H. A. Charipper, R. Gaunt).

Pomerat, Charles Marc, A.B., A.M., Ph.D., Prof. Anat., Texas, (Galveston) (J. O. Foley, R. F. Blount).

Reinhardt, William Oscar, A.B., M.D., Instr. and Asst. Prof. Anat., Calif. (H. M. Evans, W. R. Lyons).

Rhines, Ruth, B.S., M.S., Ph.D., Instr. Anat., Northwestern (W. F. Windle, H. W. Magoun).

Richter, Kenneth Murrel, B.A., M.A., Ph.D., Asst. Prof. Hist. and Embryol., Oklahoma (J. M. Thuringer, C. F. DeGaris).

Riley, Henry Alsop, B.A., A.M., M.D., Prof. Clin. Neur., Columbia (F. A. Mettler, B. Campbell).

Robertson, George Gordon, B.A., B.Sc., Ph.D., Instr. Anat., Baylor (A. A. Pearson, J. S. Nicholas).

Saunders, Richard L. de C. H., M.B.Ch.B., M.D., Assoc. Prof. Anat., Dalhousie (D. Mainland, J. C. B. Grant).

Sawyer, Charles Henry, A.B., Ph.D., Assoc. Anat., Duke (J. E. Markee, W. H. Hollinshead).

Sensenig, E. Carl, B.A., M.S., Ph.D., Prof. Anat. (temp.), Oglethorpe (C. M. Goss, J. O. Foley).

Shryock, Edwin Harold, B.S., M.A., M.D., Asst. Prof. Anat., Coll. Med. Evangelists (G. H. Scott, E. Gardner).

Singer, Marcus, B.S., A.M., Ph.D., Instr. Anat., Harvard (G. B. Wislocki, H. L. Weatherford).

Turner, Robert S., A.B., Ph.D., Asst. Prof. Anat., Stanford (C. H. Danforth, D. J. Gray).

Washburn, Sherwood L., A.B., Ph.D., Asst. Prof. Anat., Columbia (S. R. Detwiler, P. E. Smith).

Wilson, James G., B.A., M.A., Ph.D., Instr. Anat., Rochester (K. E. Mason, C. E. Tobin).

Woerner, Charles Arthur, B.S., Ph.D., M.D., Instr. Anat., N. Y. Med. Coll. (C. E. Tharaldsen, E. W. Count).

Number of members:

Number of members May 1, 1943		760
Deceased	2	
Resigned	1	3
		757
New provisional members endorsed April, 1944		33
Number of members May 1, 1944		790

8. It was suggested that W. W. Greulich be named in place of Philip E. Smith as a delegate to the Council of the A.A.A.S. for 1944, since the A.A.A.S. will meet in Cleveland during the summer of 1944. Voted by the Executive Committee.

9. The Executive Committee was asked to "vote on the question of the advisability of planning a general meeting in 1945." The vote of the Committee was 9–2 in favor of a 1945 meeting. As a result of this vote, steps will be taken to arrange such a meeting.

10. In response to the suggestion of two members, the Executive Committee was asked to vote on the advisability of the appointment of a committee to study and report on the question of the growing shortage of human dissecting material. The vote was: 3 in favor; 7 against; 1 not voting. Opinion was expressed that many of the problems relating to the supply of cadavera are local, their solution depending upon the activities of the anatomists in each individual state. It may be added that certain phases of the problem have been under investigation within the past three years by the Bureau of Legal Medicine and Legislation of the American Medical Association.

The 1944 Sectional Meetings

In response to authorization by the Executive Committee, two sectional meetings were again organized, and again, as in 1943, they were held in Philadelphia and Chicago respectively.

The Philadelphia Sectional Meeting. For the second successive year, The Wistar Institute of Anatomy and Biology acted as host to the meeting, which was held on Friday, May 5. Invitations to participate were limited to places within a 70 mile radius of Philadelphia. The program consisted of morning and afternoon sessions for reading of papers and an evening invitation lecture. Throughout the day there was on display the newly arranged Wistar Institute exhibit of skeletons selected from specimens produced in Dr. Charles R. Stockard's famous cross-breeding experiments on dogs.

The meeting was high-lighted by the evening invitation lecture by Dr. George L. Streeter, who gave a remarkably lucid account of the early development of the human embryo, as divided into successive stages, or "horizons." The talk was so informative, inspiring and delightful that many expressed the hope that Dr. Streeter might on some occasion present it at a full meeting of the Association.

There was a very informal Dinner, attended by 27 persons; no Smoker. The Local Committee was made up of representatives of medical schools in Philadelphia, with Dr. J. P. Schaeffer, Chairman, Dr. E. J. Farris, Secretary, and Dr. E. R. Clark, Program. Forty persons registered, of whom thirty were members of the Association.

The program was as follows:

(Abstracts of most of the papers presented at Philadelphia and of some of the Chicago papers will be found in The Anatomical Record, v. 88, no. 4, April, 1944.)

Friday, May 5, 10:00 a. m.

1. Direct observations on the effect of hemorrhage upon the mesenteric blood vessels and blood flow, as seen in the dog. R. G. Abell and I. H. Page, University of Pennsylvania and the Lilly Laboratory for Clinical Research.
2. The extent of the carotid pressoreceptor area in the cat as indicated by its special elastic-tissue wall. W. H. F. Addison, University of Pennsylvania.
3. An experimental technic utilizing the 'lymph sac' of the thyroid gland (cat). A. J. Ramsay, Daniel Baugh Institute of Anatomy, Jefferson Medical College.
4. Growth and behavior of epidermis as observed microscopically in the living, in chambers introduced in the rabbit's ear. E. R. Clark and E. L. Clark, University of Pennsylvania.
5. Nerve cells in tissue culture. M. J. Hogue, University of Pennsylvania.
6. The contractile tension of the blastodisc gel layer of the zebra fish egg undergoes rhythmic variations synchronous with mitosis. Illustrated with a motion picture. W. H. Lewis, The Wistar Institute of Anatomy and Biology.
7. Influence of testosterone propionate on the adrenals and testes of hypophysectomized rats. J. H. Leathem, Rutgers University.
8. Pattern of cyclic activity of women. E. J. Farris, The Wistar Institute of Anatomy and Biology.

2:00 p. m.

9. Senile changes in the brain of Wistar Institute rats. H. Kuhlenbeck, Woman's Medical College of Pennsylvania.
10. Pigmentation of certain mesencephalic tegmental nuclei in the dog and cat. J. O. Brown, University of Pennsylvania (introduced by E. R. Clark).
11. Polarity in the nerve cells of molluscs. G. S. de Renyi, University of Pennsylvania.
12. Cell number — volume relationship in the medullary plate of Amblystoma punctatum. C. Hutchinson, Daniel Baugh Institute of Anatomy, Jefferson Medical College.
13. Experiments on the decussation and course of Mauthner's fibers in Amblystoma puctatum. J. Piatt, University of Pennsylvania.
14. The venous return from the head and neck. O. V. Batson, Graduate School of Medicine, University of Pennsylvania.
15. Variations in the blood-supply of the liver, gall-bladder, duodenum, and pancreas. N. A. Michels, Daniel Baugh Institute of Anatomy, Jefferson Medical College.
16. Racial and functional investigation of the temporomandibular joint. J. L. Angel, Daniel Baugh Institute of Anatomy, Jefferson Medical College (introduced by J. P. Schaeffer).

8:00 p. m.

Dr. George L. Streeter,
Syndromic characters in the organogenesis of the human embryo.

A Chicago Regional Meeting was held at Northwestern University Medical School and adjoining Wesley Memorial Hospital, Chicago, on Friday, April 28 and Saturday, April 29, under the auspices of a local committee made up of representatives of the medical schools in Chicago, with L. B. Arey, Chairman, and H. W. Magoun, Secretary.

In addition to the presentation of papers, demonstrations and motion pictures in scheduled sessions, an informal dinner, with 75 in attendance, was held on Friday evening with Prof. M. J. Herskovits of Northwestern University as guest speaker on ''African elements in Brazilian life.'' Following the dinner and preceding an ensuing smoker, this splendid letter of greeting from Acting President of the Association, J. Parsons Schaeffer, was read and was enjoyed by all:

Dear Doctor Arey:

I take pleasure in sending greetings and well wishes to the group of members and guests of the American Associaton of Anatomists now gathered in regional conference in Chicago.

As Acting President of the Association I much regret that circumstances over which I have no control prevent meeting with you. I hoped that it might be otherwise, but the accelerated teaching program and other duties incident to the war effort, as well as the absence of a number of my teaching staff in military service preclude leaving my laboratory at this time. Added to this, the Philadelphia anatomists will hold a local meeting at The Wistar Institute early in May.

Although it is unfortunate that the American Association of Anatomists as a whole cannot meet in regular session this year owing to war conditions, the assemblage of local, sectional and regional groups of anatomists and their participation in live programs is, I believe, of fundamental importance. Through this effort the continuity of annual anatomical gatherings and conferences is maintained during these troublesome times.

While recognizing the wide influence and value of the general annual meeting of the American Association of Anatomists, one must not minimize the important role that may be served through sectional and regional meetings. In the general meeting, because of the size of the program, it has become necessary to have a number of sections participating in programs simultaneously. This, of course, has led to division of the members into groups, in accord with primary interests. While this method has value, probably not unlike that of the symposium, it is not without its shortcomings. I must admit that where and when possible, I am partial to meetings in which all participants are privileged to hear all of the papers and discussions and see all of the exhibits, although diverse the fields of inquiry and presentations may be.

The importance of becoming competent, in the sense of a final court, in a special field of investigation, even though narrow in scope, is, I venture to say, recognized by all. One must, however, not forget the unity of education and learning. Anatomy in a broad biological sense has many ramifications and often the individual research worker has become so absorbed in a given division of anatomy that he is no longer able to be critical of his own researches in reference to their relationship to the whole or the significance of such studies as related to the wider biological field. To listen to a mixed program throughout, is definitely of value. The importance comes to the individual listener when he attempts to correlate and integrate the subject matter presented in a series of papers. It becomes important that the specialist or the worker in an isolated field listens to and learns of facts and hypotheses which would, perhaps, on first thought appear entirely foreign to his own field of work yet often in reality are not.

Because of these observations I wish to congratulate you and your associates on the interesting and balanced program which you are now presenting in your regional meeting. To have the privilege of meeting as one body and to participate actively in the entire program is, I believe, the real strength of the sectional meeting. Your program again gives evidence that American Anatomy at the present time is motivated from the point of view that it is a broad biological science ramifying in all phases of structure, function, the genetic background. environmental influences, the functional interrelations of systems, et cetera, et cetera.

The spirit and scope of American Anatomy today need no defense. Just as medicine in general cannot advance by practice alone so anatomy in America has taken the forefront position that it cannot survive nor satisfactorily serve the general biological and medical programs by continuing merely to fill the role of a handmaid to certain clinical subjects. Although anatomy is more and more becoming an independent science as compared with former days, it is fully recognized that the subject is not self-contained or self-sufficient. It assumes the right to move into and to utilize related and cognate fields of science in the solution of its varied problems. Without reservation I feel that American Anatomy and its Association are now serving both the general biological field and medicine and medical education in a praiseworthy manner.

With reference to medicine, anatomy is primarily functioning in a three-fold program: First, it is vitally concerned with the undergraduate courses in the ancillary divisions of the science; second, through pure and applied research American Anatomy has become a living and growing science and is constantly essaying an important role not only in curative medicine but in preventive medicine as well, a point of view that is often not appreciated by the ill-informed critics of our science; and third, the application of anatomy and its correlation with clinical work is, I believe, more effectively accomplished at the present time than ever before in the history of anatomy. There has developed a helpful and coordinating spirit between the anatomists working in varied fields and the associated clinical groups in many of the laboratories and hospitals of America.

All Hail! Let us not turn back but continue forward.

With high regards and best wishes to all, I am

Very cordially yours,

J. PARSONS SCHAEFFER

April 24, 1944

The program was as follows:

Friday, April 28, 10:00 a. m.

Spontaneous glomerulonephritis in mice. A Kirschbaum, University of Minnesota.

Phosphorus turn-over in red and white fat as shown by ingested radio-active phosphorus. J. L. Littrell, D. E. Martin and C. G. Hartman, University of Illinois.

The state of glycogen in the liver cell. A. Lazarow (introduced by N. L. Hoerr), Western Reserve University.

Experimental observations on the origin and function of the tissue basophile or mast cell. W. L. Simpson and W. Cramer, Barnard Free Skin and Cancer Hospital and Washington University.

The similarity of neuroglia to other connective tissue. W. Andrew and C. T. Ashworth, Southwestern Medical College.

The effect of peripheral factors on mitotic activity and cellular differentiation of motor neurons in the chick embryo. V. Hamburger, Washington University.

Damming of axoplasm in constricted nerve: A sign of perpetual growth in nerve fibers. P. Weiss, University of Chicago.

Formation of commissures in surgically altered brains of chick embryos. R. Rhines (introduced by W. F. Windle), Northwestern University.

The thyroid gland of choline deficient mice. J. H. Van Dyke, Washington University.

Observations on pre- and postpubertal oogenesis in the albino rat. K. Christensen and J. R. Ring, St. Louis University.

The role of the thecal cone in ovulation. L. B. Arey and E. J. Cummins, Northwestern University.

Occurrence of cystic ovaries in thyroidectomized rats treated with diethylstilbestrol. R. G. Janes, Wayne University.

Descensus testiculorum: (a) Descent after severance of gubernaculum and (b) Androgenic stimulation of the scrotum, inguinal bursa and ductus deferens. L. J. Wells, University of Minnesota.

Modifications of the testis and epididymis in rats following feeding of human diets low in the vitamin B complex. A. J. Gatz, G. M. Higgins and R. D. Williams, Loyola University and Mayo Foundation.

Friday, April 28, 2: 00 p. m.

The masticatory apparatus of the bradypodidae. H. Sicher (introduced by I. Schour), Loyola University.

An hereditary dental anomaly in the albino rat. I. Schour, M. Massler and R. O. Greep, University of Illinois.

The early relations of the notochord to other structures in the roof of the pharynx of the pig. J. A. Miller, University of Tennessee.

Perichondrial ossification and the fate of the perichondrium; with special reference to that of the otic capsule. T. H. Bast, University of Wisconsin.

The human stapes: A nonconformist among bones. B. J. Anson, E. W. Cauldwell and A. F. Reimann, Northwestern University.

Friday, April 28, 3: 30 p. m.

Demonstrations and motion pictures:

The elephant's brain. G. von Bonin, University of Illinois.

Electroarchitectonics — A correlative study of structure and function in the central nervous system. B. Campbell, University of Minnesota.

Damming of axoplasm in constricted nerve: A sign of perpetual growth in nerve fibers. P. Weiss, University of Chicago.

Comparison of effects of ischemia, concussion and axon reaction on nissl-body patterns of nerve cells. W. F. Windle, R. A. Groat and C. A. Fox, Northwestern University.

Reconstruction of chromatolysed ventral horn cells of the monkey. R. Novick (introduced by B. Campbell), University of Minnesota.

The true relationship of fibers to cells in neuroglial tissue. W. Andrew and C. T. Ashworth, Southwestern Medical College.

An iron-alum hematoxylin method for myelinated nerve fibers. W. T. Niemer (introduced by A. R. Vonderahe), University of Cincinnati.

Vascularization of the neural tube of the embryo rabbit. L. H. Strong, University of Michigan.

A direct method for determining drug induced changes in the sensitivity of the respiratory center. J. Wells and W. A. Rambach (introduced by W. F. Windle), Northwestern University.

Models of human internal ears to demonstrate the size, shape and location of the cristae of the ampulla and the maculae of the sacculus and utriculus. T. H. Bast, University of Wisconsin.

Models illustrating the development of the human stapes. B. J. Anson, E. W. Cauldwell and A. F. Reimann, Northwestern University.

X-ray views of sections of the human body. H. O. Mahoney and B. J. Anson, Northwestern University.

The differential staining of bone and cartilage in gross specimens cleared by Groat's method. C. O. Bechtol (introduced by H. W. Mossman), Wisconsin General Hospital and University of Wisconsin.

Fusion of the cartilaginous anlage; a stage in normal joint development. O. A. Mortensen, University of Wisconsin.

The temporomandibular joint. L. Misurarca, O. Otto and R. Stone (introduced by W. Sullivan), University of Wisconsin.

Photographs showing various stages in the dissection of pygopagus twins, aged 4 months 16 days. H. Dawson, State University of Iowa.

The anatomy of an agnathic human fetus. H. H. Scudamore (introduced by L. B. Arey), Northwestern University.

Development of adrenocortical-like tissue in the ovary of the ground squirrel after adrenalectomy. R. A. Groat, Northwestern University.

The thecal cone of ovarian follicles. E. J. Cummins (introduced by L. B. Arey), Northwestern University.

Responses of developing Cowper's and Bartholin's glands of the opossum to hormones. D. Rubin (introduced by C. R. Moore), University of Chicago.

A steer heart with a large anastomosis between the left coronary artery and the apex of the left ventricle. H. W. Mossman, University of Wisconsin.

The gavel of the Chicago Anatomical Society, with an historical note. W. F. Windle, Northwestern University.

Corticospinal tract lesions in the monkey. B. W. Cannon and E. Cowgill (introduced by W. F. Windle), Northwestern University. (Motion picture).

Asphyxia neonatorum. An experimental study in the guinea pig. W. F. Windle and R. F. Becker, Northwestern University. (Motion picture).

The behavior of lymph vessels in the wing of the living bat. R. L. Webb and P. A. Nicol, University of Illinois and Indiana University. (Motion picture).

Saturday, April 29, 10:00 a. m.

Reproduction in female rats after ablation of the pelvic nerves. E. J. Kollar (introduced by O. F. Kampmeier), University of Illinois.

The distribution of nerve cells and fibers to the choledochoduodenal junction of the cat. E. A. Boyden and C. Van Buskirk, University of Minnesota.

The distribution of myelinated afferent fibers in the peripheral branches of the cat facial nerve. S. R. Bruesch, University of Tennessee.

An electroarchitectonic study of the spinal cord following retrograde degeneration. B. Campbell, University of Minnesota.

Concussion of the spinal cord. R. A. Groat, W. A. Rambach and W. F. Windle, Northwestern University.

Structural alterations in the brain in and after experimental concussion. W. F. Windle, R. A. Groat and C. A. Fox, Northwestern University.

The intramedullary course of afferent vagus fibers. W. R. Ingram and E. Dawkins, State University of Iowa.

Time relations and temporal facilitation of a trigeminal reflex pathway. W. Hille (introduced by B. Campbell), University of Minnesota.

Symptomology of herpes simplex infection in rabbits. R. Good and B. Campbell, University of Minnesota.

The oculomotor nucleus in the human fetus. A. A. Pearson, Loyola University and Baylor University.

Thalamic damage after asphyxia at birth. R. F. Becker, W. F. Windle and E. F. Hunter, Northwestern University.

Physiological neuronography of some cortico-subcortical connections in the chimpanzee. H. W. Garol and W. S. McCulloch (intorduced by G. von Bonin), University of Illinois.

A study of the brain of Galago: Its relation to the pattern of the primate cortex. G. von Bonin, University of Illinois.

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AREY, LESLIE B., Ph.D., Sc.D., (Ex. Com. '30–'34, Second Vice-Pres. '42–), Robert Laughlin Rea Professor of Anatomy, and Chairman of the Division of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

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BAILEY, PERCIVAL, M.D., Ph.D., Professor of Neurology and Neurosurgery, *University of Illinois, 1853 W. Polk St., Chicago, Ill.*

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BARRY, ALEXANDER, A.B., M.A., Ph.D., Instructor in Anatomy, University of Michigan Medical School, *1430 Golden Ave., Ann Arbor, Mich.**

BARTELMEZ, GEORGE W., Ph.D. (Vice-Pres. '32–'34, Exec. Com. '36–'40). Professor of Anatomy, *The University of Chicago, Chicago, Ill.*

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BAST, T. H., B.A.. Ph.D., Professor of Anatomy, *University of Wisconsin, 308 Science Hall, Madison, Wis.*

BATSON, O. V., A.M., M.D., Professor of Anatomy, *Department of Anatomy, Graduate School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

BAUMGARTNER, WILLIAM J., A.B., A.M., Ph.D., Professor of Zoology, University of Kansas, *1209 Ohio St., Lawrence, Kan.*

BEAMS, HAROLD W., Ph.D., Professor of Zoology, *State University of Iowa, Iowa City, Ia.*

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BÉLANGER, LEONARD F., A.B., M.D., A.M., Assistant Professor of Histology and Embryology, *University of Montreal, Montreal, Canada.**

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BENSLEY, SYLVIA H., A.B., M.D., Assistant Professor of Anatomy, *Department of Anatomy, The University of Chicago, Chicago, Ill.*

BENTON, JOSEPH G., A.B., M.S., Ph.D., Research Associate, Department of Obstetrics and Gynecology (Lecturer in Physiology and Hygiene, Hunter College), *New York University, College of Medicine, 477 First Ave., New York City.**

BERRY, CHARLES M., A.B., M.S., Ph.D., Instructor in Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

BEST, R. RUSSELL, B.Sc., M.D., Assistant Professor of Anatomy, Associate Professor of Surgery, University of Nebraska, College of Medicine, *527 Medical Arts Building, Omaha, Neb.**

BEVELANDER, GERRIT, Ph.D., Associate Professor of Anatomy, *New York University, 477 First Ave., New York City.*

BIGELOW, ROBERT P., S.B., Ph.D., Professor Emeritus of Zoology and Parasitology, Massachusetts Institute of Technology, *72 Blake Rd., Brookline, Mass.*

BISHOP, KATHERINE SCOTT, A.B., M.D., *1508 La Loma Ave., Berkeley, Calif.*

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BLINCOE, HOMER, A.B., M.S., M.D., Professor of Anatomy, *Emory University, Emory, Ga.*

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BLOUNT, RAYMOND FRANK, M.S., Ph.D., Professor of Anatomy, *Department of Anatomy, University of Texas, Medical Branch, Galveston, Tex.*

BLUMENFELD, CHARLES M., Ph.D., M.D., *Institute of Pathology, Western Reserve University, Cleveland, O.*

BODIAN, DAVID, S.B., Ph.D., M.D., Associate in Epidemiology, *Johns Hopkins University School of Hygiene and Public Health, Poliomyelitis Laboratory, Baltimore, Md.**

BOGART, RALPH, B.S., M.S., Ph.D., Agent in Animal Husbandry, Bureau of Animal Industry, U. S. D. A., Instructor in Animal Husbandry, *University of Missouri, 324 Mumford Hall, Columbia, Mo.*

BOLING, JOHN L., A.B., Ph.D., Instructor in Anatomy, *College of Medicine, New York University, 477 First Ave., New York City 16.*

BOOK, M. H., M.D., Instructor in Anatomy, *Tufts College Medical School, 416 Huntington Ave., Boston, Mass.*

BOWIE, DONALD J., B.Sc., Med., M.A., Ph.D., Assistant Professor of Anatomy, *Medical College, Winnipeg, Manitoba, Canada.*

BOYD, EDITH, M.D., Superintendent of Whitefish Hospital, *Whitefish, Mont.*

BOYDEN, EDWARD ALLEN, A.M., Ph.D. (Ex. Com. '28–'32, '39–), Professor of Anatomy and Chairman of Department, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

BOYER, ESTHER L., M.A., Ph.D., M.D., *University Hospitals, Columbia, Mo.*

BRADBURY, JAMES T., B.S., M.S., Sc.D., Endocrinologist, *Bureau of Dairy Industry, U. S. Department of Agriculture, Beltsville, Md.*

BRADLEY, E. MORTON, B.A., Ph.D., Assistant Professor of Gross Anatomy, *University of Georgia School of Medicine, Augusta, Ga.*

BRASHEAR, ALTON D.. A.B., M.S., D.D.S., F.A.C.D., Associate Professor of Anatomy, *Medical College of Virginia, Richmond, Va.**

Bremer, John Lewis, A.B., M.D. (Ex. Com. '15–'18, '33–'37), Hersean Professor of Anatomy Emeritus, *Harvard Medical School, Boston, Mass.*

Brewer, John I., S.B., M.D., Ph.D., Associate in Gynecology, Northwestern University Medical School and St. Luke's Hospital, Chicago, *104 S. Michigan, Chicago, Ill.**

Brodie, Allan G., D.D.S., Ph.D., Professor of Orthodontia and Head of the Department, *College of Dentistry, University of Illinois, 30 N. Michigan Ave., Chicago, Ill.*

Browman, Ludvig G., Ph.D., Associate Professor in Zoology and Physiology, *Montana State University, Missoula, Mont.*

Brown, James O., B.S., M.S., Ph.D., Instructor in Anatomy, *School of Medicine, University of Pennsylvania, Philadelphia 4, Pa.*

Brues, Austin Moore, A.B., M.D., Assistant Professor of Medicine, Harvard Medical School; Assistant Physician, *Massachusetts General Hospital, Boston, Mass.*

Bruesch, Simon Rulin, A.B., M.S., M.B., Ph.D., M.D., Instructor in Anatomy, *University of Tennessee College of Medicine, Memphis, Tenn.*

Bryce, Thomas H., M.A., M.D., F.R.S., Emeritus Professor of Anatomy, University of Glasgow, *The Loaning, Peebles, Scotland.*

Buchanan, A. R., B.S., M.S., M.D., Associate Professor of Anatomy, *University of Colorado Medical School, 4200 E. Ninth Ave., Denver, Colo.*

Bueker, Elmer D., B.S., M.A., Ph.D., Instructor in Anatomy, *Medical College of the State of South Carolina, Charleston, S. C.*

Bullard, H. Hays, A.M., Ph.D., M.D., *18 Tracy St., Rochester 7, N. Y.*

Bullock, Theodore H., B.A., Ph.D., Instructor in Neuro-anatomy, *Yale University School of Medicine, 333 Cedar St., New Haven, Conn.*

Bunting, Charles Henry, B.S., M.D., Professor of Pathology, *University of Wisconsin, Service Memorial Institute, Madison, Wis.*

Burack, Ethel, A.B., Ph.D., Assistant Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

Burns, B. I., A.B., A.M., Ph.D., M.D., Professor of Anatomy; Dean, School of Medicine, *Louisiana State University, 1542 Tulane Ave., New Orleans, La.*

Burns, Robert K., Jr., A.B., Ph.D., Research Associate, Department of Embryology, *Carnegie Institution of Washington, Wolfe and Madison Sts., Baltimore, Md.*

Burr, Harold Saxton, Ph.D., (Ex. Com. '29–'33), E. K. Hunt Professor of Anatomy, Head of Section of Neuro-Anatomy, School of Medicine, Yale University, *333 Cedar St., New Haven, Conn.*

Burrows, Montrose T., A.B., M.D., Physician and Surgeon, *201 North El Malino Ave., Pasadena, Calif.*

Butcher, Earl O., A.M., Ph.D., Assistant Professor of Anatomy, *College of Dentistry, New York University, New York City.*

Butler, Elmer G., A.M., Ph.D., Sc.D., Professor of Zoology, *Laboratory of Comparative Anatomy, Princeton University, Princeton, N. J.*

Calkins, Leroy A., M.D., M.S., Ph.D., Professor of Obstetrics and Gynecology, *University of Kansas Hospital, Kansas City, Kan.*

Cameron, Angus L., A.B., M.S., M.D., Ph.D., *Northwest Clinic, Minot, N. Dak.*

Cameron, John A., A.B., A.M., Ph.D., Professor of Anatomy, *Baylor University, College of Dentistry, Dallas, Tex.*

Campbell, Berry, A.B., Ph.D., Assistant Professor of Anatomy, *Medical School, University of Minnesota, Minneapolis, Minn.*

Candela, Pompeo B., M.D., Research Associate in Anatomy, New York Medical College, *576 18th St., Brooklyn, N. Y.*

Carey, Eben J., M.S., Sc.D., M.D., Dean and Professor of Anatomy and Director of Anatomy Department, Marquette University School of Medicine, *6119 W. Wisconsin Ave., Wauwatosa, Wis.*

Carpenter, Russel L., B.S., Ph.D., Professor of Zoology, *Tufts College, Boston, Mass.*

Carver, Gail L., A.B., A.M., Professor of Biology, *Mercer University, Macon, Ga.*

Casamajor, Louis, A.M., M.D., Professor of Clinical Neurology, *Columbia University, 706 West 168th St., New York City.*

Casey, Albert E., M.D., Pathologist, Baptist, Children's, Holy Name of Jesus and Jefferson Hospitals, *1907 Wellington Rd., Birmingham, Ala.*

Castelnuovo, Gina, Ph.D., Instructor in Anatomy, *Woman's Medical College of Pennsylvania, Philadelphia, Pa.*

Chambers, Robert, Jr., A.M., Ph.D. (Second Vice-Pres. '39–'40), Research Professor of Biology, *New York University, New York City.*

Chandler, Simon B., A.B., A.M., M.D., Professor of Anatomy, *West Virginia University School of Medicine, Morgantown, W. Va.*

Chang, Chun, M.D., Associate Professor of Anatomy, *National Medical College of Shanghai, 373 Ave. Haig, Shanghai, China.*

Charipper, Harry A., B.S., M.S., Ph.D., Professor of Biology (Tissue Cytology, Endocrinology, Histology and Comparative Haematology), Chairman of Department, *Washington Square College, New York University, New York City.*

Charles, Cecil M., A.B., M.A., Ph.D., M.D., Associate Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

Chase, Philena Evans, B.A., Ph.D., with the American Red Cross for the duration. *56 Leland St., Portland, Me.*

Chase, Ralph E., A.B., B.Sc., A.M., Instructor in Anatomy, *Oklahoma University Medical School, Oklahoma City, Okla.*

Chase, Samuel Wood, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, *Western Reserve University, 2109 Adelbert Road, Cleveland, O.*

Cherner, Maxwell, M.D., Police and Fire Surgeon, Dept. of Public Safety, Phila., Medical Examiner, Reading Railroad, *1902 North 22nd St., Philadelphia, Pa.*

Child, Charles Manning, M.S., Ph.D., D.Sc., Professor Emeritus of Zoology, *Jordan Hall, Stanford University, Calif.*

Chouke, Kehar S., M.A., M.D., Assistant Professor of Anatomy, *Graduate School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

Christensen, Kermit, Ph.D., Assistant Professor of Microanatomy, *St. Louis University School of Medicine, 1402 South Grand Blvd., St. Louis, Mo.*

Clark, Eleanor Linton, A.M., Voluntary Research Worker, Department of *Anatomy, Medical Department, University of Pennsylvania, Philadelphia, Pa.*

Clark, Eliot R., A.B., M.D., ScD. (Ex. Com. '16–'19, Sec.-Treas. '38–'42; Sec.-Treas. '42–), Professor of Anatomy and Director of Department of Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

CLARK, GEORGE, Ph.D., Assistant Professor of Psychobiology, *Yerkes Laboratories of Primate Biology, Orange Park, Fla.*

CLARK, SAM L., M.S., Ph.D., M.D., (Ex. Com. '42–) Professor of Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*

CLAUSEN, HARRY J., A.B., M.S., Ph.D., Assistant Professor of Anatomy, *University of Colorado School of Medicine, Denver, Colo.*

CLEMENTS, LEO, Ph.D., Associate Professor of Anatomy, Member Nebraska Basic Science Board, *Creighton University Medical School, Omaha, Neb.*

CLEVELAND, RUCKER, Ph.D., Junior Research Worker, *Research Laboratories, Parke, Davis and Co., Detroit 32, Mich.*

COBB, W. MONTAGUE, A.B., M.D., Ph.D., Professor of Anatomy, *Howard University, 520 W. St., N. W., Washington, D. C.*

COE, WESLEY R., Ph.D., Professor of Biology Emeritus, *Yale University, Osborn Zoological Laboratory, New Haven, Conn.*

COHN, ALFRED E., A.B., M.D., Member, *Rockefeller Institute for Medical Research, New York City, N. Y.*

COLE, ARCH EVAN, B.A., Ph.D., Associate Professor in Anatomy, *University of Louisville; School of Medicine, 101 W. Chestnut St., Louisville, Ky.*

COLE, ELBERT C., Ph.D., Professor of Biology, *Williams College, Williamstown, Mass.*

COLE, HAROLD H., Ph.D., Associate Professor of Animal Husbandry, University of California, and Associate Animal Husbandman, *Experiment Station of the College of Agriculture, Davis, Calif.*

COLLINGS, M. RAYMOND, A.B., M.D., Professor of Anatomy, Medical College, Wayne University, *1512 St. Antoine St., Detroit, Mich.*

COMAN, DANA, A.B., A.M., M.D., *145 West 57th St., New York City 19.*

CONEL, JESSE LEROY, A.M., Ph.D., Professor of Anatomy, Boston University School of Medicine, *45 Arlington St., Newton, Mass.*

CONGDON, EDGAR DAVIDSON, Ph.D., Professor of Anatomy, *Long Island College of Medicine, 350 Henry St., Brooklyn, N. Y.*

CONKLIN, EDWIN GRANT, A.M., Ph.D., Sc.D., LL.D., Professor Emeritus of Biology, Princeton University, *139 Broadmead Ave., Princeton, N. J.*

COPENHAVER, WILFRED M., A.B., Ph.D., Associate Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

CORBIN, KENDALL B., A.B., M.D., Professor of Microscopic Anatomy; Chief, Division of Anatomy; in charge of Neurology, Department of Neurology and Psychiatry, *University of Tennessee College of Medicine, 875 Monroe, Memphis, Tenn.*

COREY, EDWARD LYMAN, A.B., Ph.D., Assistant Professor of Physiology, *University of Virginia School of Medicine, University, Va.**

CORNER, GEORGE W., A.B., M.D. (Ex. Com. '26–'30, '38–'42; Sec.-Treas. '30–'38), Director, Department of Embryology, *Carnegie Institution of Washington, Wolfe and Madison Sts., Baltimore, Md.*

CORNING, H. K., M.D., Professor of Anatomy (retired), *1107 Fifth Ave., New York City.*

COUNT, EARL W., A.B., B.D., Ph.D., Associate Professor of Anatomy, *New York Medical College, Flower and Fifth Avenue Hospitals, New York City.*

Covell, W. P., M.S., Ph.D., M.D., Lecturer in Otology, Rhinology and Laryngology, University of California Medical Center; Associate Professor of Research Medicine, *George Williams Hooper Foundation, San Francisco, Calif.*

Cowdry, Edmund V., Ph.D. (Ex. Com. '26–'30, 1st Vice-Pres. '34–'36), Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

Crafts, Roger Conant, B.S., Ph.D., Assistant Professor of Anatomy, *Boston University School of Medicine, 80 E. Concord St., Boston, Mass.*

Craigie, E. Horne, B.A., Ph.D. (Ex. Com. '41–), Associate Professor of Comparative Anatomy and Neurology, *Department of Biology, University of Toronto, Toronto 5, Canada.*

Crosby, Elizabeth Caroline, M.S., Ph.D., Professor of Anatomy, University of Michigan, *Department of Anatomy, University of Michigan, Ann Arbor, Mich.*

Crouch, Richard L., Ph.D., M.D., Associate Professor of Anatomy, *University of Missouri, Columbia, Mo.**

Cuajunco, Fidel, M.D., Assistant Professor of Anatomy, College of Medicine, University of the Philippines, *620 Colorado St., Manila, P. I.*

Cullen, Thomas S., M.B., D.Sc., LL.D. (Tor.), Emeritus Professor of Gynecology, Johns Hopkins University, Visiting Gynecologist to the Johns Hopkins Hospital, *20 E. Eager St., Baltimore, Md.*

Cummins, Harold, AB., Ph.D. (Ex. Com. '36–'40), Professor and Head of Division of Microscopic Anatomy, *Tulane University Medical School, Department of Anatomy, Sta. 20, New Orleans, La.*

Cunningham, Robert S., B.S., A.M., M.D., Sc.D. (Ex. Com. '32–'36), Professor of Anatomy and Dean, Albany Medical College; Administrator, Albany Hospital, *47 New Scotland Ave., Albany 3, N. Y.*

Curtis, George M., A.M., Ph.D., M.D., Professor of Surgery and Chairman of the Department of Research Surgery, *Kinsman Hall, Ohio State University, Columbus, O.*

Curwen, Alice O., Ph.D. (Mrs. Edward F. McKeen), *Bucksport, Me.*

Cutuly, Eugene, B.S., M.S., Ph.D., Pfc. U. S. Army, ASTP, *Wayne University College of Medicine, 1512 St. Antoine St., Detroit 26, Mich.**

Dalton, Albert J., B.S., M.A., Ph.D., Cytologist, *National Cancer Institute, National Institute of Health, Bethesda, Md.*

Danforth, Charles Haskell, A.B., A.M., Ph.D., Sc.D., (Ex. Com. '27–'31, Second Vice-Pres. '36–'38), Professor of Anatomy, *Stanford University, Stanford University, Calif.*

D'Angelo, Savino Albert, B.S., M.S., Ph.D., Assistant Instructor in Biology, Washington Square College, New York University, *2906 21st Ave., Astoria, L. I.**

Dardinski, Vincent J., A.B., M.A., M.D., Ph.D., Associate Professor of Pathology, Georgetown Medical School; Director of Laboratories, Georgetown University Hospital, *Georgetown University Hospital, Washington, D. C.*

Daron, Garman H., B.S., Ph.D., Associate Professor of Anatomy, *Georgetown University, School of Medicine, Washington, D. C.*

Darrach, William, A.B., A.M., M.D., Sc.D., LL.D., Professor of Clinical Surgery and Dean Emeritus of Faculty of Medicine, College of Physicians and Surgeons, Columbia University, *180 Fort Washington Ave., New York City.*

DART, RAYMOND A., M.D., Ch.M., M.Sc., Professor of Anatomy and Dean of Faculty of Medicine, *University of the Witwatersrand, Johannesburg, Transvaal, So. Africa.*

DAVENPORT, H. A., M.D., Associate Professor of Anatomy, *Northwestern University Medical School, Chicago, Ill.**

DAVIS, CARL L., M.D., Professor of Anatomy, University of Maryland School of Medicine, *Lombard and Greene Sts., Baltimore, Md.*

DAVIS, WARREN B., M.D., D.Sc., F.A.C.S., Clinical Professor of Oral Surgery, Jefferson Medical College; Maxillo-Facial Surgeon, Jefferson Hospital; Consulting Maxillo-Facial Surgeon, Kensington Hospital and Frankford Hospital; *135 S. 18th St., Philadelphia, Pa.*

DAWSON, ALDEN B., A.B., Ph.D., D.Sc., Professor of Zoology and Chairman of the Department of Biology, Harvard University, *Biological Laboratories, Harvard University, Cambridge, Mass.*

DAWSON, HELEN L., B.S., M.S., Ph.D., Assistant Professor of Anatomy, *The State University of Iowa, College of Medicine, Iowa City, Ia.*

DAY, CAMERON D., Ph.D., Professor of Zoology, *Westminister College, Fulton, Mo.*

DECARLO, JOHN, M.D., Associate in Topographic and Applied Anatomy, Jefferson Medical College, *1629 S. Broad St., Philadelphia, Pa.*

DEES-MATTINGLY, MARIE, A.B., B.S., M.D., Associate Professor of Anatomy, *Tulane University of Louisiana, New Orleans, La.*

DE GARIS, CHARLES F., M.D., Ph.D., F.A.C.P., Professor of Anatomy and Head of the Department, *University of Oklahoma, School of Medicine, Oklahoma City, Okla.*

DEIGNAN, STELLA L., B.S., M.S., Ph.D., Consultant, Work Projects Administration, *Apt. 3, 1945 Calvert St., N.W., Washington, D. C.*

DEMPSEY, EDWARD W., Ph.D., Assistant Professor of Anatomy, *Harvard Medical School, 25 Shattuck St., Boston, Mass.*

DEMPSTER, WILFRID TAYLOR, Sc.D., Instructor in Anatomy, *University of Michigan Medical School, Ann Arbor, Mich.*

DERBYSHIRE, ARTHUR J., Ph.D., Assistant Professor of Anatomy, *Wayne University School of Medicine, 1512 St. Antoine St., Detroit, Mich.*

DE RÉNYI, GEORGE S., M.D., Associate Professor of Anatomy, University of Pennsylvania, School of Medicine, *212 S. 39th St., Philadelphia, Pa.*

DE ROBERTIS, EDUARDO D. P., Member of Staff of Institute of General Anatomy, *University of Buenos Aires, Faculty of Medicine, Cangallo 2447, Buenos Aires, Argentina.*

DETWILER, SAMUEL RANDALL, Ph.B., A.M., Ph.D., M.S. (Hon.), (Ex. Com. '30–'34), Professor of Anatomy, Executive Officer of the Department, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

DEY, FREDERICK L., A.B., M.S., Ph.D., Research Fellow, Institute of Neurology, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

DOAN, CHARLES A., B.S., M.D., Professor and Chairman, Department of Medicine, and Director of Medical Research, *Ohio State University, Kinsman Hall, Columbus, O.*

DODDS, GIDEON S., M.A., Ph.D., Professor of Histology and Embryology, *West Virginia University Medical School, Morgantown, W. Va.*

DOMM, L. VALENTINE, A.B., Ph.D., Research Associate in Zoology, *Whitman Laboratory for Experimental Zoology, The University of Chicago, Chicago, Ill.*

DONALDSON, JOHN C., Ph.B., M.D., Professor of Anatomy, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

DOUGHERTY, THOMAS F., Ph.D., Research Assistant (rank of Instructor) in Anatomy, *Yale University Medical School, 333 Cedar St., New Haven, Conn.*

DOW, ROBERT S., A.B., M.A., M.D., Ph.D., Associate Professor of Anatomy and Clinical Instructor in Neurology, *University of Oregon Medical School, Portland. Ore.*

DOWNEY, HAL, A.M., Ph.D., Professor of Anatomy, *University of Minnesota Medical School, Minneapolis, Minn.*

DRAGER, GLENN A., B.S., M.S., Ph.D., Instructor in Anatomy, *University of Texas, Medical Branch, Galveston, Tex.*

DUBOIS, FRANKLIN S., A.B., M.S., M.D., *Silver Hill, New Canaan, Conn.*

DUESBERG, JULES, M.D., Professor of Anatomy, *University of Liege, 22 quai Mativa, Liege, Belgium.*

DUKE, KENNETH L., A.B., Ph.D., Associate in Anatomy, *Duke University School of Medicine, Durham, N. C.*

DUNCAN, DONALD, B.A., M.A., Ph.D., Professor of Anatomy, *Louisiana State University Medical School, New Orleans, La.*

DUSHANE, GRAHAM PHILLIPS, Ph.D., Assistant Professor of Zoology, *The University of Chicago, Chicago, Ill.*

EARLE, WILTON R., Ph.D., Cytologist, *National Cancer Institute, Bethesda, Md.*

EASTLICK, HERBERT L., A.B., M.S., Ph.D., Assistant Professor of Zoology, *Washington State College, Pullman, Wash.*

EDWARDS, EDWARD A., M.D., Instructor in Anatomy, Harvard Medical School, *23 Bay State Rd., Boston, Mass.**

EDWARDS, J. GRAHAM, M.A., Ph.D., Associate Professor of Anatomy, University of Buffalo School of Medicine, *24 High St., Buffalo, N. Y.*

EDWARDS, LINDEN F., B.A., M.S., Ph.D., Professor of Anatomy, Ohio State University College of Medicine, *Hamilton Hall, Columbus, O.*

ELFTMAN, ALICE G., A.B., A.M., Ph.D., Instructor in Biological Sciences, *Hunter College, New York City.*

ELFTMAN, HERBERT, Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

ELLIOTT, HARRY CHANDLER, A.B., M.A., Ph.D., Research Fellow, U. S. Research Council, *Department of Anatomy, University of Toronto, Toronto, Canada.*

ELLIOTT, RUSH, A.B., A.M., Ph.D., Professor of Anatomy, *Department of Zoology, Ohio University, 3 Marietta Ave., Athens, O.*

ELWYN, ADOLPH, A.M., Associate Professor of Neuroanatomy, *Columbia University, 630 West 168th St., New York City.*

EMERSON, HENRY S., B.A., Ph.D., *Department of Biology, Amherst College, Amherst, Mass.*

EMERY, FREDERICK E., Ph.D., Associate Professor of Physiology, *University of Buffalo, Buffalo, N. Y.*

EMMEL, VICTOR M., A.B., Sc.M., Ph.D., Instructor in Anatomy, *The University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

Enders, Robert K., Ph.D., Associate Professor, *Edward Martin Biological Laboratory, Swarthmore College, Swarthmore, Pa.*

Engle, Earl Theron, A.B., A.M., Ph.D., Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

Esaki, Shiro, M.D., Ph.D., Member of Anatomical Institute, *Keio University, Sasuke 666, Kamakura, Japan.*

Essenberg, J. M., Ph.D., Associate Professor of Anatomy, *Loyola University School of Medicine, Chicago, Ill.*

Essick, Charles Rhein, B.A., M.D., *700 Centre Ave., Reading, Pa.*

Etkin, William, Ph.D., Instructor in Comparative Anatomy, *College of the City of New York, New York City.*

Ettinger, George Harold, B.A., M.D.C.M., F.R.S.C., Professor of Physiology, *Queen's University, Kingston, Ontario, Canada.*

Evans, F. Gaynor, B.A., M.A., Ph.D., Assistant Professor of Anatomy, *University of Maryland Medical School, Baltimore, Md.*

Evans, Herbert McLean, B.S., M.D., M.D. honoris causa, Freiberg (Ex. Com. '19–'22; **Pres.** '30–'32), Hertzstein Professor of Biology, Professor of Anatomy and Director of the Institute of Experimental Biology, *University of California, Berkeley, Calif.*

Evans, Thomas Horace, M.D., Research Professor of Anatomy, New York Medical College and Flower-Fifth Ave. Hospital; *350 South Main St., Freeport, N. Y.*

Everett, John W., A.B., Ph.D., Assistant Professor of Anatomy, *Duke University School of Medicine, Durham, N. C.*

Everett, Newton B., B.S., M.S., Ph.D., Instructor in Anatomy, *University of Michigan, Ann Arbor, Mich.*

Eversole, Wilburn J., A.B., M.Sc., Ph.D., Instructor of Biology, *The Rice Institute, Houston, Tex.*

Fankhauser, Gerhard, Ph.D., Associate Professor of Biology, *Princeton University, Princeton, N. J.*

Faris, Hervey S., A.B., A.M., Ph.D., M.D., Practicing Physician and Surgeon, *115 South Stone Ave., Tucson, Ariz.*

Farris, Edmond J., Ph.D., Associate in Anatomy, Executive Director, *The Wistar Institute of Anatomy, Woodland Ave. and 36th St., Philadelphia, Pa.*

Figge, F. H. J., Ph.D., Associate Professor of Anatomy, *University of Maryland School of Medicine, Baltimore, Md.*

Flexner, Louis Barkhouse, S.B., M.D., Research Associate, *Department of Embryology, Carnegie Institution, Wolfe and Madison Sts., Baltimore, Md.*

Fogg, Lloyd C., B.S., M.S., Ph.D., Assistant Professor of Histology and Embryology, *Boston University Medical School, 80 E. Concord St., Boston, Mass.*

Foley, James Owen, M.S., Ph.D., Associate Professor of Anatomy, *University of Alabama School of Medicine, University, Ala.*

Forbes, Thomas R., A.B., Ph.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Forman, Jonathan, A.B., M.D., Lecturer on Diseases Due to Allergy in the Ohio State University, *394 East Town St., Columbus, O.*

Foust, H. L., D.V.M., Professor of Veterinary Anatomy, *Iowa State College, Ames, Ia.*

Fox, Clement A., B.S., M.A., Ph.D., Associate Professor of Anatomy, *Temple University Medical School, Philadelphia, Pa.*

Francis, C. C., M.D., Senior Instructor in Anatomy, *Western Reserve University School of Medicine, Cleveland, O.**

Fraser, Doris Acorn, Ph.D., *333 South 22nd St., Philadelphia 3, Pa.*

Frazer, John Ernest, D.Sc., F.R.C.S., Professor of Anatomy, University of London, *St. Mary's Hospital Medical School, London, W., England.*

French, H. E., M.S., M.D., Professor of Anatomy and Dean of the School of Medicine, *University of North Dakota, Grand Forks, N. Dak.*

Freudenberger, Clay B., Ph.D., M.D., Associate Dean and Professor of Anatomy, *University of Utah School of Medicine, Salt Lake City, Utah.*

Friedman, Sydney M., B.A., M.D., M.S., Teaching Fellow in Anatomy, McGill University, *2101 University St., Apt. 32, Montreal, Canada.*

Gage, Simon Henry, B.S., (Charter member; Ex. Com. '06–'11), Professor of Histology and Embryology, Emeritus, *Stimson Hall, Cornell University, Ithaca, N. Y.*

Gamble, Dean L., B.S., Ph.D., President, Ward's Natural Science Establishment, *P. O. Box 24, Beechwood Station, Rochester, N. Y.*

Garcia, Arturo, A.B., M.D., Professor of Anatomy and Head of Department, College of Medicine, University of the Philippines, *619 Colorado St., Manila, P. I.*

Gardner, Ernest, M.D., Assistant Professor of Anatomy, *School of Medicine, University of Southern California, Los Angeles, California.*

Gardner, William U., Ph.D., Professor of Anatomy and Chairman of the Department, *Yale University School of Medicine, 333 Cedar St., New Haven, Conn.*

Garrett, Frederic D., A.B., Ph.D., Instructor in Anatomy, *University of Nebraska, College of Medicine, 42nd and Dewey Ave., Omaha, Neb.*

Gatz, Arthur J., B.A., M.A., Ph.D., Assistant Professor of Anatomy, *Loyola University, School of Medicine, 706 So. Wolcott Ave., Chicago 12, Ill.*

Gaunt, Robert, Ph.D., Associate Professor of Biology, *New York University, Washington Square E., New York City.*

Geist, Frederick D., M.D., Associate Professor of Anatomy, *University of Wisconsin, Science Hall, Madison, Wis.**

George, Ruggles Kerr, B.A., M.B., D.P.H., Assistant Professor of Anatomy, *University of Toronto, Toronto 5, Canada.*

George, Wesley Critz, A.B., A.M., Ph.D., Professor of Histology and Embryology, *University of North Carolina Medical School, Chapel Hill, N. C.*

Gersh, Isidore, A.B., Ph.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.**

Gey, George O., B.S., M.D., Instructor in Surgery, Johns Hopkins Hospital and University, *Johns Hopkins Medical School, Baltimore, Md.*

Gillilan, Lois A., B.A., A.M., Ph.D., Instructor in Anatomy, *University of Pittsburgh Medical School, Department of Anatomy, Pittsburgh, Pa.*

Globus, J. H., B.S., M.D., Associate Professor of Neuro-Anatomy, New York University, *960 Park Ave., New York City.*

GODWIN, MELVIN C., A.B., Ph.D., Assistant Professor of Anatomy and Histology, *West Virginia University Medical School, Morgantown, W. Va.*

GOLDNER, JACQUES WILHELM, M.D., Resident Pathologist, *Free Hospital for Women, 245 Pond Ave., Brookline 46, Mass.*

GOLDSMITH, ELI D., M.S., Ph.D., Instructor in Biology, College of the City of New York and New York University, *Washington Square College, New York University, New York City.*

GOLDSMITH, JOSEPH B., M.A., Ph.D., Associate Professor of Histology and Embryology, *Oklahoma University School of Medicine, Oklahoma City, Okla.**

GOMEZ, E. T., Ph.D., Assistant Physiologist, *Division of Nutrition and Physiology, Bureau of Dairy Industry, U. S. Department of Agriculture, Beltsville Research Center, Beltsville, Md.*

GOODRICH, HUBERT BAKER, B.S., M.A., Ph.D., Professor of Biology, *Wesleyan University, Middletown, Conn.*

GORDON, ALBERT S., B.S., M.S., Ph.D., Assistant Professor of Biology, *Washington Square College, New York University, New York City.*

GOSS, CHARLES MAYO, A.B., M.D., Professor of Anatomy, *University of Alabama, School of Medicine, Tuscaloosa, Ala.*

GOULD, HARLEY NATHAN, A.B., A.M., Ph.D., Professor of Biology, *Newcomb College, Tulane University, New Orleans, La.*

GRAFFLIN, ALLAN L., A.B., M.D., Assistant Professor of Anatomy, *Harvard Medical School, Boston, Mass.**

GRANT, J. C. BOILEAU, M.B., Ch.B., F.R.C.S. (Edin.), Professor of Anatomy, *University of Toronto, Toronto, Canada.*

GRANT, MADELEINE P., S.B., M.A., Ph.D., Member Teaching Staff in Zoology, *Sarah Lawrence College, Bronxville, N. Y.*

GRAVES, WILLIAM W., M.D., Professor and Director, Department of Neuropsychiatry, *St. Louis University School of Medicine, St. Louis, Mo.*

GRAY, DONALD J., B.S., M.S., Ph.D., Assistant Professor of Anatomy, *Stanford University, Stanford, Calif.*

GRAY, MARY E., B.A., Ph.D., Assistant, *Department of Anatomy, Vanderbilt University, Nashville, Tenn.*

GRAY, PETER, Ph.D., D.I.C., Associate Professor of Biology, *University of Pittsburgh, Pittsburgh, Pa.*

GREENE, CHARLES W., A.M., Ph.D. Professor Emeritus of Physiology and Pharmacology, University of Missouri, *814 Virginia Ave., Columbia, Mo.*

GREENE, EUNICE C., A.M., Research Investigator, *Syracuse University School of Medicine, Syracuse, N. Y.*

GREENE, WALTER FARRER, A.B. Ph.D., Associate Professor of Anatomy, *College of Medicine, Syracuse University, Syracuse, N. Y.*

GREENHILL, J. P., B.S., M.D., F.A.C.S., Professor and Vice Chairman, Department of Obstetrics and Gynecology, Loyola University Medical School; Professor of Gynecology, Cook County Graduate School of Medicine; Attending Gynecologist, Cook County Hospital, *Suite 2805–06 Pittsfield Building, 55 East Washington St., Chicago, Ill.*

GREEP, ROY O., M.S., Ph.D., Research Associate, *Squibb Institute for Medical Research, New Brunswick, N. J.*

GREGORY, WILLIAM KING, A.B., A.M., Ph.D., Sc.D., Da Costa Professor of Vertebrate Palaeontology, Columbia University; Chairman, Departments of Comparative Anatomy and Ichthyology, *American Museum of Natural History, New York City 24.*

GREULICH, WILLIAM W., M.A., Ph.D., Professor of Physical Anthropology and Anatomy and Director of the Brush Foundation, *Western Reserve University School of Medicine, 2109 Adelbert Rd., Cleveland, O.*

GROAT, RICHARD A., B.A., M.S., Ph.D., Assistant Professor of Neurology, *Institute of Neurology, Northwestern University Medical School, Chicago 11, Ill.*

GRODINSKY, MANUEL, B.Sc., M.D., Associate Professor of Anatomy and Surgery, University of Nebraska, College of Medicine, *681 N. 58th St., Omaha, Neb.*

GRUENWALD, PETER, M.D., Assistant Professor of Histology, *Middlesex University School of Medicine, Waltham, Mass.*

GUDERNATSCH, F., Ph.D., Visiting Professor, Graduate School, *New York University, Washington Square East, New York City.*

GUILD, STACY R., A.M., Ph.D. (Ex. Com. '39–), Associate Professor of Otology and Director of Otological Research Laboratory, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

GURDJIAN, ELISHA STEPHENS, A.B., M.S., M.D., Ph.D., F.A.C.S., Neuro-Surgeon, Grace Providence and Receiving Hospitals; Instructor in Surgery, Wayne University, *840 David Whitney Bldg., Detroit, Mich.*

GUTHRIE, MARY J., A.B., A.M., Ph.D., Professor of Zoology, *210 Lefevre Hall, University of Missouri, Columbia, Mo.*

GUTTMACHER, ALAN F., A.B., M.D., Associate Professor of Obstetrics, Johns Hopkins University, *1039 N. Calvert St., Baltimore, Md.*

GUYER, MICHAEL F., Ph.D., LL.D., Professor of Zoology, *University of Wisconsin, Madison, Wis.*

HAIR, GENE W., Ph.D., Instructor in Anatomy, *University of Buffalo, School of Medicine, Buffalo, N. Y.*

HALL, B. VINCENT, A.B., Ph.D., Assistant Professor of Zoology, *University of Illinois, Urbana, Ill.*

HALL, BYRON E., Ph.D., M.D., *Mayo Clinic, Rochester, Minn.*

HALL, EDMUND K., D.Sc., Ph.D., Assistant Professor of Anatomy, *University of Louisville Medical School, Louisville, Ky.*

HALL, E. RAYMOND, Ph.D., Associate Professor of Vertebrate Zoology and Curator of Mammals, *Museum of Vertebrate Zoology, University of California, Berkeley, Calif.*

HALPERT, BÉLA, M.D., Director of Laboratories of the University Hospitals and Professor of Clinical Pathology, *University of Oklahoma School of Medicine, 800 East 13th St., Oklahoma City, Okla.*

HAM, ARTHUR W., M.B., Associate Professor of Anatomy, *University of Toronto, Toronto, Canada.*

HAMBLEN, E. C., M.D., Associate Professor of Obstetrics and Gynecology, *Duke University School of Medicine, Durham, N. C.*

HAMBURGER, VIKTOR, Ph.D., Professor of Zoology, *Washington University, St. Louis, Mo.*

HAMILTON, JAMES B., Ph.D., Associate Professor of Anatomy, *University of Missouri, School of Medicine, Columbia, Mo.*

HAMLETT, GEORGE W. D., A.B., A.M., Ph.D., Research Agent, *U. S. Biological Survey, Department of Embryology, Carnegie Institution of Washington, Baltimore, Md.**

HAMMOND, WARNER S., Ph.D., Assistant Professor of Anatomy, *Cornell University Medical College, New York City 21.*

HANAN, ERNEST B., A.B., A.M., M.D., Chief Pathologist of Burge Hospital School of Nursing, *600 Medical Arts Building, Springfield, Mo.*

HANSON, FRANK BLAIR, A.B., A.M., Ph.D., Associate Director, *The Rockefeller Foundation, 49 West 49th St., New York City.*

HARD, WALTER LEON, A.B., Ph.D., Assistant Professor of Histology, *University of Maryland School of Medicine, Baltimore, Md.*

HARDESTY, IRVING, A.B., Ph.D., Sc.D. (Ex. Com. '10 and '12–'15, '22–'23), Emeritus Professor of Anatomy and Head of Department of Anatomy, School of Medicine, *Tulane University, 1301 Pine St., New Orleans, La.*

HARE, W. KENDRICK, A.B., M.S., Ph.D., Associate Professor of Anatomy, *State University of Iowa, Iowa City, Ia.*

HARGITT GEORGE T., A.B., A.M., Ph.D., Sc.D., Professor of Zoology, *Biology Bldg., Duke University, Durham, N. C.*

HARMAN, PINCKNEY J., B.S., M.S., Ph.D., Instructor in Anatomy, *Georgetown University School of Medicine, 3900 Reservoir Rd., N. W., Washington, D. C.*

HARRIS, HENRY A., M.A., M.D., B.S., M.R.C.P., D.Sc., Professor of Anatomy, *The Anatomy School, The University, Cambridge, England.*

HARRISON, FRANK, B.S., Ph.D., Assistant Professor of Anatomy, *University of Tennessee, Memphis, Tenn.*

HARRISON, ROSS GRANVILLE, Ph.D., M.D., Sc.D., LL.D., (Press. '12–'14), Chairman, National Research Council; Sterling Professor of Biology and Director of Osborn Zoological Laboratory Emeritus, *Yale University, New Haven, Conn.*

HARTMAN, CARL G., M.A., Ph.D. (Ex. Com. '29–'33) (First Vice-Pres. '40–'42), Professor of Zoology, Head of Department of Zoology and Physiology, Chairman Division of Biological Sciences, *University of Illinois, Urbana, Ill.*

HARVEY, BASIL COLEMAN HYATT, A.B., M.D., Professor of Anatomy Emeritus, *The University of Chicago, Chicago, Ill.*

HASHIMOTO, EDWARD I., A.B., M.D., M.S., Associate Professor of Anatomy, *University of Utah Medical School, Salt Lake City, Utah.*

HATERIUS, HANS OLIVER, A.B., M.S., Ph.D., Professor of Physiology, *Wayne University College of Medicine, Detroit, Mich.*

HAUSMAN, LOUIS, A.B., M.D., Associate Professor of Neurology, Cornell Medical College; Associate Visiting Physician, Neurological Service, Cornell Division, Bellevue Hospital, *140 E. 54th St., New York City.*

HEINBECKER, PETER, M.D., Associate Professor of Surgery, *Washington University Medical School, St. Louis, Mo.*

HELDT, THOMAS J., A.B., A.M., M.D., Physician in Charge of Division of Neuropsychiatry, *Henry Ford Hospital, Detroit, Mich.*

HELFF, O. M., B.S., M.S., Ph.D., Associate Professor of Biology, *New York University, University Heights, New York City.*

HELLBAUM, ARTHUR A., Ph.D., M.D., Associate Professor of Pharmacology, *University of Oklahoma, School of Medicine, Oklahoma City, Okla.*

Herrick, Charles Judson, Ph.D., (Ex. Com. '13–'17), Emeritus Professor of Neurology, The University of Chicago, *236 Morningside Drive, Grand Rapids 6, Mich.*

Hertig, Arthur T., M.D., Assistant Professor of Pathology and Assistant Professor of Obstetrics, Harvard Medical School; Pathologist and Visiting Obstetrician to Outpatients, Boston Lying-in Hospital; Pathologist, Free Hospital for Women, Brookline, Mass.; *221 Longwood Ave., Boston, Mass.*

Hertzler, Arthur E., B.S., A.M., Ph.D., M.D., LL.D., D.Sc., F.A.C.S., Professor of Surgery, *University of Kansas, Halstead, Kan.*

Hetherington, Albert W., B.S., Ph.D., Instructor in Neurology, *Northwestern University Medical School, Chicago, Ill.*

Hetherington, Duncan Charteris, A.B., M.A., Ph.D., M.D., Associate Professor of Anatomy, *Duke University Medical School, Durham, N. C.*

Heuser, Chester H., A.M., Ph.D., Research Associate, Department of Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

Higgins, George M., A.M., Ph.D., Associate Professor of Experimental Biology, *University of Minnesota, Mayo Foundation, Rochester. Minn.*

Hill, James Peter, D.Sc., F.R.S., Professor Emeritus of Embryoloy, *Royal College of Surgeons, Lincoln's Inn Fields, London, W.C. 2, England.*

Hill, John E., A.B., Ph.D., Assistant Curator of Mammals, *American Museum of Natural History, 79th St. and Central Park West, New York City.*

Hill, Robert T., Ph.D., Associate Professor of Anatomy, *Indiana University, Medical School, Bloomington, Ind.*

Hilton, William A., B.S., Ph.D., Professor of Zoology, Pomona College, Director Laguna Marine Laboratory, *1263 Dartmouth Ave., Claremont, Calif.*

Hines, Marion, A.B.. Ph.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Hinsey, Joseph C., M.S., Ph.D. (Ex. Com. '40–), Dean and Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

Hirsch, G. Christian, Ph.D., Lector, Head of Department of Experimental Histology, *Zoological Laboratory. The University, Utrecht, Janskerkhof 3, Holland.*

Hisaw, Frederick L., A.B., A.M., Ph.D., LL.D., Professor of Zoology, Chairman of the Department of Biology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

Hoadley, Leigh, A.B., Ph.D., Professor of Zoology, *Harvard University, Cambridge. Mass.*

Hoerr, Normand L., A.B., Ph.D., M.D., Professor of Anatomy, *School of Medicine, Western Reserve University, 2109 Adelbert Rd., Cleveland, O.*

Hogg, Ira D., B.A., M.A., Ph.D., Assistant Professor of Anatomy, Department of Anatomy, University of Pittsburgh School of Medicine, *617 Hampton Ave., Wilkinsburg, Pa.*

Hogue, Mary J., Ph.D., Associate in Anatomy, *University of Pennsylvania Medical School, Philadelphia, Pa.*

Hollinshead, W. Henry, A.B., M.S., Ph.D., Assistant Professor of Anatomy, *Duke University School of Medicine, Durham, N. C.*

Holt, Caroline M., A.B., A.M., Ph.D., Professor of Biology and Public Health, *Simmons College, 38 Ridge Ave., Newton Centre, Mass.*

Holyoke, Edward A., M.D., Ph.D., Associate Professor of Anatomy, *University of Nebraska, College of Medicine, 42nd and Dewey Ave., Omaha, Neb.*

Hooker, Charles W., Ph.D., Assistant Professor of Anatomy, *Yale University School of Medicine, New Haven, Conn.*

Hooker, Davenport, Ph.D., Sc.D. (Ex. Com., '22–'25) (Second Vice-Pres. '40–'42), Professor of Anatomy and Head of the Department, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

Hopkins, Grant Sherman, Sc.D., D.V.M., Emeritus Professor of Comparative Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*

Hoskins, Margaret Morris, Ph.D., Associate Professor of Microscopic Anatomy, *New York University Dental College, 477 First Ave., New York City.*

Howe, Howard A., M.D., Associate Professor of Epidemiology, *Johns Hopkins University School of Hygiene and Public Health, Baltimore, Md.*

Howell, A. Brazier, Associate Professor of Anatomy, *Department of Anatomy, Johns Hopkins Medical School, Baltimore, Md.*

Howland, Ruth B., Ph.D., Associate Professor of Biology, Washington Square College, *New York University, Washington Square East, New York City.*

Hoy, Wm. E., A.B., Ph.D., Professor of Biology and Head of the Department of Biology, *University of South Carolina, Columbia, S. C.*

Huber, John Franklin, A.M., M.D., Ph.D., Professor and Head of the Department of Anatomy, *School of Medicine, Temple University, Broad St. at Ontario, Philadelphia 40, Pa.*

Hughson, Walter, S.B., M.D., Director Otological Research Laboratory, *Abington Memorial Hospital, Abington. Pa.*

Humm, Frances Dorris, Ph.D., Research Assistant in Embryology, *Yale University, Osborn Zoological Laboratory, New Haven, Conn.*

Hummel, Katharine P., Ph.D., Research Associate, *Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.*

Humphrey, Rufus R., A.M., Ph.D., Professor of Anatomy, School of Medicine, University of Buffalo, *24 High St., Buffalo, N. Y.*

Humphrey, Tryphena, M.D., Ph.D., Assistant Professor of Anatomy, *University of Pittsburgh School of Medicine, Pittsburgh, Pa.*

Hunt, Thomas E., A.B., Ph.D., Associate Professor of Histology and Embryology, *University of Alabama Medical School, University, Ala.*

Hunter, Oscar B., A.B., A.M., M.D., Professional Lecturer, Georgetown University, *1835 Eye St., N. W., Washington, D. C.*

Hutchinson, Cranford, Ph.D., Associate in Anatomy, *Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia 7, Pa.*

Ingalls, N. William, B.S., M.D., Associate Professor of Anatomy, School of Medicine, *Western Reserve University, 3526 Edison Road, Cleveland Heights, O.*

Ingersoll, Everett H., B.S., M.S., Ph.D., Associate Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*

Ingram, W. R., M.S., Ph.D., Professor and Head, Department of Anatomy, *State University of Iowa, College of Medicine, Iowa City, Ia.*

Jackson, Clarence M., M.S., M.D., LL.D., (Ex. Com. '10–'14, '23–'28, Vice-Pres. '16–'17. Pres. '22–'23), Professor Emeritus of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

JACKSON, JOSEPH L., M.A., M.B., Professor of Anatomy, *University of Saskatchewan, Saskatoon, Canada.*

JAILER, JOSEPH WILLIAM, B.S., M.S., Ph.D., M.D., Research Assistant in Anatomy, *College of Physicians and Surgeons, Columbia University, New York City.*

JANES, RALPH G., A.B., B.S., M.S., Ph.D., Assistant Professor of Anatomy, *Wayne University School of Medicine, 1512 St. Antoine St., Detroit, Mich.*

JEFFERS, KATHARINE R., Ph.D., Assistant Professor of Zoology, *Duke University, Durham, N. C.*

JENKINS, GEORGE B., M.D., Professor of Anatomy and Director of Anatomy Department, *George Washington University Medical School, Washington, D. C.*

JOB, THESLE T., A.B., M.S., Ph.D., Professor of Anatomy, *Loyola University School of Medicine, 706 South Wolcott Ave., Chicago, Ill.*

JOHNSON, MYRA L., A.B., A.M., Ph.D., Assistant Professor of Zoology, *Smith College, 14 Henshaw Ave., Northampton, Mass.**

JOHNSON, SYDNEY E., Ph.D., M.D., F.A.C.P., Professor of Gross Anatomy, School of Medicine, University of Louisville, *101 West Chestnut St., Louisville, Ky.*

JOHNSTON, THOMAS BAILLIE, M.D., Professor of Anatomy, University of London, *Guy's Hospital Medical School, London, S. E. 1, England.*

JOHNSTONE, PAUL N., A.B., M.D., Instructor in Surgery, University of Kansas Medical School, *210 Argyle Bldg., Kansas City, Mo.**

JONES, DAVID S., Ph.D., Assistant Professor of Anatomy, *Loyola University Medical School, 706 S. Wolcott St., Chicago, Ill.*

JONES, OLIVER P., A.B., Ph.D., Professor and Head of the Department of Anatomy, *University of Buffalo, School of Medicine, 24 High St., Buffalo, N. Y.*

JONES, RUSSELL, Ph.D., Assistant Professor of Anatomy, *Indiana University School of Medicine, Bloomington, Ind.*

JORDAN, HARVEY ERNEST, A.M., Ph.D., Sc.D., (Ex. Com. '18–'21) (First Vice-Pres. '36–'38), Dean of the Department of Medicine, Professor of Anatomy and Director of the Anatomical Laboratories, *Pavilion VIII, East Lawn, University of Virginia, Charlottesville, Va.*

JOY, EDWARD A., A.B., A.M., Ph.D., Associate Professor of Anatomy, *Tufts College Medical School, 416 Huntington Ave., Boston, Mass.*

KAAN, HELEN WARTON, Ph.D., Associate Professor of Zoology, *Wellesley College, Wellesley, Mass.*

KABAT, HERMAN, Ph.D., M.D., Passed Assistant Sanitarian (R), *U. S. Public Health Service, Bethesda, Md.**

KAMMERAAD, ADRIAN, A.B., Ph.D., Instructor in Anatomy, *Louisiana State University School of Medicine, 1542 Tulane Ave., New Orleans, La.**

KAMPMEIER, OTTO FREDERIC, A.B., Ph.D., M.D., Professor of Anatomy and Head of Department, *College of Medicine, University of Illinois, 1853 W. Polk St., Chicago, Ill.*

KAPPERS, CORNELIUS UBBO ARIËNS, M.D., Sc.D., T.D., Director of the Central T.L.L. Institute for Brain Research of Holland; *Professor of Comparative Neurology, University of Amsterdam, Mauritskade 61, Amsterdam, Holland.*

KAYLOR, CORNELIUS T., A.B., M.S., Ph.D., Assistant Professor of Anatomy, *College of Medicine, Syracuse University, Syracuse, N. Y.*

KEITH, SIR ARTHUR, M.D., LL.D., F.R.C.S., D.Sc., F.R.S., Master of *Buckston Browne Research Farm, Downe, Kent, England.*

KELLOGG, REMINGTON, Ph.D., Curator, Division of Mammals, *U. S. National Museum, Washington, D. C.*

KELLY, G. LOMBARD, A.B., B.S., M.D., Dean and Professor of Anatomy, *University of Georgia, School of Medicine, Augusta, Ga.*

KERNAN, JOHN D., JR., A.B., M.D., Professor of Oto-Laryngology, Columbia College of Physicians and Surgeons, *103 East 78th St., New York City.*

KEY, J. ALBERT, B.S., M.D., Clinical Professor of Orthopedic Surgery, *Washington University, St. Louis, Mo.*

KILLE, FRANK R., Ph.D., Assistant Professor of Zoology, *Swarthmore College, Swarthmore, Pa.*

KIMMEL, DONALD L., Ph.D., Associate Professor of Anatomy, *School of Medicine, Temple University, Broad St. at Ontario, Philadelphia, Pa.*

KINDRED, JAMES ERNEST, A.B., A.M., Ph.D., Associate Professor of Anatomy, *University of Virginia Medical School, Box 1341, University Station, Charlottesville, Va.*

KING, HELEN DEAN, A.M., Ph.D., Member of The Wistar Institute (Experimental Zoology), *The Wistar Institute of Anatomy, 36th St. and Woodland Ave., Philadelphia, Pa.*

KING, JESSIE L., Ph.D., Professor of Physiology, *Goucher College, Baltimore, Md.*

KINGERY, HUGH MCMILLAN, A.B., A.M., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Colorado, Denver, Colo.*

KINGSBURY, BENJAMIN F., A.B., Ph.D., M.D., D.Sc. (Ex. Com. '22–'25, Vice-Pres. '32–'34), Professor Emeritus of Histology and Embryology, Cornell University, Ithaca, N. Y., *211 Glenburnie St., Chapel Hill, N. C.*

KINGSLEY, D. M., M.S., Ph.D., M.D., Assistant Visiting Surgeon to Charity Hospital, *15 Fontainebleau Drive, New Orleans, La.**

KIRKHAM, WILLIAM BARRI, Ph.D., Consulting Director, Museum of Natural History, *220 State St., Springfield 5, Mass.*

KIRKMAN, HADLEY, A.B., S.M., Ph.D., Associate Professor of Anatomy, *Stanford University, Calif.*

KIRSCHBAUM, ARTHUR, Ph.D., M.D., Assistant Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

KNISELY, MELVIN H., Ph.D., Assistant Professor of Anatomy, *The University of Chicago, Chicago, Ill.*

KNOUFF, R. A., B.A., M.A., Ph.D., Professor of Anatomy, *Department of Anatomy, Ohio State University, Columbus, O.*

KOCH, JOHN C., B.S., M.D., *1053 Iroquois Ave., Detroit 14, Mich.*

KOFOID, CHARLES ATWOOD, A.B., Ph.D., Sc.D., LL.D., Professor of Zoology Emeritus, *Room 5090, Life Sciences Bldg., University of California, Berkeley, Calif.*

KORNHAUSER, S. I., M.A., Ph.D., (Ex. Com. '42–), Professor of Anatomy and Executive Secretary, *University of Louisville, School of Medicine, 101 W. Chestnut St., Louisville, Ky.*

KRAFKA, JOSEPH, JR., Ph.D., M.D., Professor of Microscopic Anatomy, *University of Georgia School of Medicine, Augusta, Ga.*

KRAMER, THEODORE C., B.S., M.A., Ph.D., Instructor in Anatomy, *University of Michigan, Ann Arbor, Mich.*

KREHBIEL, ROBERT H., M.S., Ph.D., Assistant Professor of Anatomy, *University of Illinois, College of Medicine, 1853 W. Polk St., Chicago, Ill.*

KRIEG, WENDELL J. S., B.S., M.S., Ph.D., Associate Professor of Neurology, *Institute of Neurology, Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

KROGMAN, WILTON M., Ph.D., Associate Professor of Anatomy and Physical Anthropology, *Department of Anatomy, The University of Chicago, Chicago, Ill.*

KROPP, BENJAMIN, Ph.D., Assistant Professor of Embryology, *Queen's University Medical School, Kingston, Ontario, Canada.*

KUHLENBECK, HARTWIG, M.D., Ph.D., Professor of Anatomy, *Woman's Medical College of Pennsylvania, Philadelphia, Pa.*

KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D., Professor of Biology, *Lafayette College, Easton, Pa.*

KUNTZ, ALBERT, Ph.D., M.D. (Second Vice-Pres. '38–'39; First Vice-Pres. '39–'40), Professor of Micro-anatomy, *St. Louis University Medical School, 1402 South Grand Ave., St. Louis, Mo.*

KUTCHIN, MRS. HARRIET LEHMANN, A.M., *''The Maplewood,'' Green Lake, Wis.*

LACHMAN, ERNEST, M.D., Associate Professor of Anatomy, *University of Oklahoma School of Medicine, Oklahoma City, Okla.*

LAMBERT, AVERY ELDORUS, B.S., Ph.D., Professor of Histology, State University of Iowa Medical School, *Room 360, Medical Laboratories Bldg., Iowa City, Ia.*

LANGWORTHY, ORTHELLO R., A.B., A.M., M.D., Associate Professor of Neurology, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

LANIER, RAYMOND R., B.A., Ph.D., Assistant in Anatomy, *Washington University, St. Louis, Mo.*

LARSELL, OLOF, A.M., Ph.D., (Ex. Com. '38–'42), Professor of Anatomy, Dean of Graduate Division, Oregon State System of Higher Education, *University of Oregon Medical School, Portland, Ore.*

LASSEK, ARTHUR M., M.S., Ph.D., M.D., Professor of Anatomy, *Medical College of the State of South Carolina, Charleston, S. C.*

LATIMER, HOMER B., A.M., Ph.D., Professor of Anatomy, *Medical School, University of Kansas, Lawrence, Kan.*

LATTA, JOHN S., A.B., Ph.D., Professor of Anatomy, University of Nebraska, College of Medicine, *Forty-second St. and Dewey Ave., Omaha, Neb.*

LAWLESS, JOHN J., M.A., Ph.D., Physician, Student Health Service, *West Virginia University, Morgantown, W. Va.*

LAZAROW, ARNOLD, M.D., Ph.D., Senior Instructor in Anatomy, *School of Medicine, Western Reserve University, 2109 Adelbert Rd., Cleveland, O.*

LEATHEM, JAMES H., B.S., M.A., Ph.D., Assistant Professor of Zoology, *Rutgers University, New Brunswick, N. J.*

LEBLOND, CHARLES PHILIPPE, M.D., Ph.D., Lecturer in Histology and Embryology, *Department of Anatomy, McGill University, Montreal, Canada.*

LEE, FERDINAND CHRISTIAN, A.B., M.D., Associate Professor of Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

LEONARD, SAMUEL L., Ph.D., Associate Professor of Zoology, *Cornell University, Ithaca, N. Y.*

LEVENSTEIN, IRVING M., Ph.D., Endocrinologist, *Leberco Laboratories, Bloomfield, N. J.*

LEVI, GIUSEPPE, M.D., Former Professor of Anatomy, *Institut d'Anatomie pathol., 1, rue des Bonnes Villes, Liege, Belgique.*

LEWIS, FREDERIC T., A.M., M.D., (Ex. Com. '09–'13, Vice-Pres. '14–'16; Pres. '36–'38), Professor of Comparative Anatomy, Emeritus, *Harvard Medical School, Boston, Mass.*

LEWIS, MARGARET REED, *The Wistar Institute, 36th St. and Woodland Ave., Philadelphia, Pa.*

LEWIS, WARREN HARMON, B.S., M.D., (Ex. Com. '09–'11, '14–'17, Pres. '34–'36), *The Wistar Institute, 36th St. and Woodland Ave., Philadelphia, Pa.*

LILLIE, FRANK RATTRAY, Ph.D., Sc.D., LL.D., Andrew MacLeish Distinguished Service Professor Embryology Emeritus, The University of Chicago, *5801 Kenwood Ave., Chicago, Ill.*

LIMSON, MARCIANO, M.D., Associate Professor of Anatomy, *College of Medicine, University of the Philippines, Manila, P. I.*

LINELL, ERIC AMBROSE, Ch.B., M.D., Professor of Neuropathology, *Banting Institute, University of Toronto, Canada.*

LIPSHUTZ, BENJAMIN, M.D., Assistant Professor in Neuro-anatomy, Jefferson Medical College, *1007 Spruce St., Philadelphia, Pa.*

LITTLE, CLARENCE COOK, B.A., M.S., Sc.D., LL.D., Litt.D., Director, *Jackson Memorial Laboratory, Bar Harbor, Me.*

LLOYD, RUTH SMITH, A.B., M.S., Ph.D., Instructor in Anatomy, *Howard University, Washington, D. C.*

LOOPER, JAMES BURDINE, Ph.D., M.D., Professor of Anatomy, *University of Mississippi, Oxford, Miss.*

LOOSLI, CLAYTON, G., M.D., Ph.D., Assistant Professor of Medicine, *The University of Chicago, Chicago, Ill.**

LORD, FREDERIC P., A.B., M.D., Professor of Anatomy, *Dartmouth Medical School, 39 College St., Hanover, N. H.*

LORENTE DE NÓ, RAPHAEL, M.D., Member, *Rockefeller Institute for Medical Research, 66th St. and York Ave., New York City 21.*

LOTH, EDWARD, M.D., Ph.D., Professor of Anatomy and Director of Anatomical Institute, University of Warsaw, *5 Chalubinski Str., Warsaw, Poland.*

LOW, FRANK NORMAN, A.B., Ph.D., Assistant Professor of Anatomy, *University of North Carolina Medical School, Chapel Hill, N. C.*

LOWREY, LAWSON GENTRY, A.M., M.D.,Psychiatrist, Brooklyn Hebrew Orphan Asylum and Travelers Aid Society, *25 West 54th St., New York City.*

LUCAS, ALFRED M., Ph.D., Associate Professor of Zoology, *Iowa State College, Ames, Ia.*

LUCAS, MIRIAM SCOTT, Ph.D., *Department of Zoology, Iowa State College, Ames, Ia.*

LYONS, WILLIAM R., B.A., M.A., Ph.D., Associate Professor of Anatomy, *University of California, Berkeley, Calif.*

MACCALLUM, DANIEL BARTLETT S.B., Ph.D., M.D., Professor of Anatomy, *University of Southern California Medical School, Los Angeles, Calif.**

MacCardle, Ross C., B.S., Ph.D., Instructor in Anatomy and Research Associate, *Washington University School of Medicine, St. Louis, Mo.**

MacEwen, Ewen, B.S., M.S., M.D., Professor of Anatomy, Director of the Anatomical Laboratories, Dean, College of Medicine, *University of Iowa, Iowa City, Ia.*

MacFall, Claude M., Ph.D., Professor of Anatomy, *George Washington Medical School, 1335 H Street, N. W., Washingtgon, D. C.*

MacFarland, Frank Mace, A.M., Ph.D., Emeritus Professor of Histology, Leland Stanford Junior University; President California Academy of Sciences, San Francisco; *775 Santa Ynez St., Stanford University, Calif.*

Macklin, C. C., M.B., M.D., M.A., Ph.D., F.R.S.C. (Ex. Com. '28–'32), Professor of Histology and Embryology, *University of Western Ontario Medical School, London, Ontario, Canada.*

Maclean, Bernice L., A.B., Ph.D., Assistant Professor of Zoology, Department of Biological Sciences, *Hunter College, 2 Park Ave., New York City.*

MacLeod, John, A.B., M.S., Ph.D., Research Associate in Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

Magath, Thomas Byrd, M.S., Ph.D., M.D., Consulting Physician, Clinical Laboratories, Mayo Clinic and Professor of Pathology and Parasitology, University of Minnesota, *Mayo Clinic, Rochester, Minn.*

Magoun, Horace W., Ph.D., Professor of Microscopic Anatomy, *Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

Magruder, Samuel R., B.S., M.A., Ph.D., Assistant Professor of Anatomy, *Tufts College Medical School, 416 Huntington Ave., Boston, Mass.*

Mahon, Eleanor Conway, Ph.D., *Iron River, Mich.*

Mainland, Donald, M.B., Ch.B., D.Sc., F.R.S.E., *Department of Anatomy, Dalhousie University, Halifax, Nova Scotia, Canada.*

Malone, Edward F., A.B., M.D. (Ex. Com. '31–'35), Francis Brunning Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, O.*

Manter, John T., Ph.D., Assistant Professor of Anatomy, *University of South Dakota, School of Medicine, Vermillion, S. Dak.*

Mark, Edward Laurens, Ph.D., LL.D., Hersey Professor of Anatomy (Emeritus), Harvard University and Trustee of the Bermuda Biological Station for Research, Inc., *109 Irving St., Cambridge, Mass.*

Markee, J. E., B.S., Ph.D., Professor of Anatomy, Head of Anatomy Department, *Duke University School of Medicine, Durham, N. C.*

Marshall, Clyde, M.D., *25 Beech St., Halifax, Nova Scotia, Canada.*

Martin, Cecil P., M.A., M.B., D.Sc., Professor of Anatomy, *McGill University, Montreal, Canada.*

Martin, John, B.S., M.S., M.B., M.D., Associate in Surgery, *Northwestern University Medical School, Chicago, Ill.**

Mason, Karl E., Ph.D., Professor of Anatomy, *The University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

Masson, Georges M. C., D.V.M., Ph.D., Research Associate, *McGill University, Montreal, Canada.*

Mastin, E. Vernon, M.D., M.S. (in Surgery), Assistant Professor of Surgery, St. Louis University Medical School, *3720 Washington Ave., St. Louis, Mo.*

Matas, Rudolph, M.D., LL.D., Sc.D., F.R.C.S. Eng. (hon.), (Charter member), Professor of Surgery (1894–1927), Emeritus (1927–), and Demonstrator of Anatomy (1885–1894), Tulane University, *2255 St. Charles Ave., New Orleans 13, La.*

Matthews, Samuel A., M.A., Ph.D., Professor of Biology, *Williams College, Williamstown, Mass.*

Mavor, James Watt, B.A., M.A., Ph.D., Professor of Biology, *Union College, Schenectady, N. Y.*

McClendon, Jesse F., Ph.D., Research Professor of Physiology, Hahnemann Medical College, *Route 1, Trooper Rd., Norristown, Pa.*

McClung, Clarence E., Ph.G., A.B., A.M., Ph.D., Emeritus Professor of Zoology, *University of Pennsylvania, Philadelphia, Pa.*

McClure, Charles Freeman Williams, A.M., Sc.D. (Vice-Pres. '10–'11, Ex-Com. '12–'16, Pres. '20–'21), Professor Emeritus of Comparative Anatomy, *Princeton University, Princeton, N. J.*

McCotter, Rollo E., M.D., Professor of Anatomy, Medical School, University of Michigan, *Lakewood R. R. 1, Ann Arbor, Mich.*

McCrady, Edward, Jr., A.B., M.S., Ph.D., Professor of Biology, *University of the South, Sewanee, Tenn.*

McGill, Caroline, A.B., A.M., Ph.D., M.D., Physician *58 W. Quartz, Butte, Mont.*

McKenzie, Fred F., B.S.A., A.M., Ph.D., D.Agr., Professor of Animal Husbandry, *Oregon State College, Corvallis, Ore.*

McKinney, Roscoe L., Ph.D., Professor of Anatomy, *Howard University, Washington, D. C.*

Mead, Harold Tupper, B.A., M.S., Ph.D., Professor of Zoology, *Erskine College, Due West, S. C.*

Meader, Ralph G., Ph.D., Assistant Professor of Anatomy, Assistant Director Board of Scientific Advisors, The Jane Coffin Childs Memorial Fund for Medical Research, *Yale University School of Medicine, 333 Cedar St., New Haven, Conn.*

Meaker, Samuel R., A.B., A.M., M.D., M.R.C.S. (Eng.), F.A.C.S., F.C.O.G., Professor of Gynaecology, Boston University School of Medicine, *475 Commonwealth Ave., Boston, Mass.*

Mendelsohn, William, M.S., M.D., Clinical Instructor in Surgery, Yale Medical School, *442 Temple St., New Haven, Conn.*

Menkin, Valy, B.S., M.A., M.D., Associate in Research, *Fearing Research Laboratory, Free Hospital for Women, Brookline, Mass.*

Merriman, Daniel, B.S., M.S., Ph.D., Assistant Professor of Biology and Director, Bingham Oceanographic Laboratory, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

Mettler, Fred A., A.M., M.D., Ph.D., Associate Professor of Anatomy, College of Physicians and Surgeons, Columbia University, Commonwealth Fund Visiting Professor of Neurology, Long Island College of Medicine, *630 West 168th St., New York City.*

Meyer, Adolf, M.D., LL.D., Professor Emeritus in Psychiatry, Johns Hopkins Hospital, *4305 Rugby Rd., Baltimore 10, Md.*

MEYER, ARTHUR W., S.B., M.D. (Ex. Com. '12–'16, Vice-Pres. '24–'25), Professor of Anatomy Emeritus, Leland Stanford Junior University, *121 Waverly St., Palo Alto, Calif.*

MEYER, ROLAND K., B.A., M.A., Ph.D., Professor of Zoology, *Department of Zoology, University of Wisconsin, Madison, Wis.*

MICHELS, NICHOLAS A., M.A., D.Sc., Associate Professor of Anatomy, *The Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pa.*

MIDLO, CHARLES, M.D., Associate Professor of Anatomy, *Tulane University, P.O. Station 20, New Orleans 15, La.*

MILLER, JAMES A., A.B., Ph.D., Instructor in Anatomy, *Division of Anatomy, College of Medicine, University of Tennessee, Memphis, Tenn.*

MILLER, ROLAND E., B.S., M.S., Ph.D., Assistant Professor of Anatomy, *Bowman Gray School of Medicine, Winston-Salem, N. C.*

MILLER, RUTH ALEXANDER, A.B., Ph.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

MILLER, RUTH N., A.B., M.D., Associate Professor of Anatomy, *Woman's Medical College of Pennsylvania, Philadelphia, Pa.*

MILLER, SHIRLEY P., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *Anatomical Institute, University of Minnesota, Minneapolis, Minn.*

MINCKLER, JEFF, Ph.D., Instructor in Anatomy, *St. Louis University School of Medicine, St. Louis, Mo.*

MONTAGU, M. F. ASHLEY, Ph.D., Associate Professor of Anatomy, *Hahnemann Medical School and Hospital, Philadelphia, Pa.*

MOODY, ROBERT ORTON, B.S., M.D., Emeritus Professor of Anatomy, University of *California, 2826 Garber St., Berkeley, Calif.*

MOORE, CARL R., A.M., Ph.D., Professor of Zoology, *Hull Zoological Laboratory, The University of Chicago, Chicago, Ill.*

MORGAN, LAWRENCE ONIS, A.B., A.M., Ph.D., Associate Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, O.*

MORISON, ROBERT S., A.B., M.D., Assistant Professor of Anatomy, *Harvard Medical School, 25 Shattuck St., Boston, Mass.*

MORRILL, CHARLES V., A.M., Ph.D., Associate Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

MORTENSEN, OTTO A., B.S., M.D., Associate Professor of Anatomy, *University of Wisconsin, Madison, Wis.*

MORTON, DUDLEY JOY, M.D., Associate Professor, Department of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

MORTON, THOMAS H., Ph.D., Professor of Biology, *Niagara University, Niagara University, N. Y.*

MOSSMAN, HARLAND W., Ph.D., Associate Professor of Anatomy, *Science Hall, University of Wisconsin, Madison, Wis.*

MYERS, BURTON D., A.M., M.D., Professor of Anatomy (retired), Indiana University School of Medicine, *424 N. Walnut St., Bloomington, Ind.*

MYERS, J. ARTHUR, M.S., Ph.D., M.D., Professor of Preventive Medicine and Chief of Chest Clinic, *University of Minnesota Medical School, Minneapolis, Minn.*

NELSON, ROSE C., B.A., M.A., Ph.D., *101 Mantle Ave., Elizabethtown, Ky.*

NELSON, WARREN O., A.B., Sc.M., Ph.D., Professor and Head of the Department of Anatomy; Chairman of the Division of Basic Medical Sciences, *Wayne University, School of Medicine, 1512 St. Antoine St., Detroit, Mich.*

NICHOLAS, JOHN SPANGLER, M.S., Ph.D., Sterling Professor of Biology, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

NIELSON, PAUL E., M.S., Ph.D., Research Assistant in Anatomy, and Research Fellow, Barnard Free Skin and Cancer Hospital, *Washington University, St. Louis, Mo.*

NIGRELLI, ROSS F., B.S., M.S., Ph.D., Pathologist, New York Aquarium, *New York Zoological Society, Bronx Park, Bronx, N. Y.*

NOBACK, CHARLES ROBERT, B.S., M.S., Ph.D., Assistant Professor of Microscopic Anatomy, *University of Georgia School of Medicine, Augusta, Ga.*

NOBACK, GUSTAVE J., B.S., M.A., Ph.D., Professor of Anatomy, New York University, *477 First Ave., New York City.*

NONIDEZ, JOSÉ F., M.S., Sc.D., Professor of Anatomy, Cornell University Medical College, *1300 York Ave., New York City.*

NORRIS, H. W., A.B., Sc.D., Research Professor of Zoology, *Grinnell College, Grinnell, Ia.*

OBENCHAIN, JEANETTE B., Ph.D., Research Associate, Department of Anatomy, *The University of Chicago, Chicago, Ill.*

ODIORNE, JOSEPH M., B.S., M.A., Ph.D., Assistant Professor of Anatomy, *Georgetown University School of Medicine, Washington, D. C.*

O'DONOGHUE, CHARLES H., D.Sc., F.Z.S., F.R.S.E., Professor of Zoology, *University of Reading, Reading, England.*

O'LEARY, JAMES L., Ph.D., M.D., Associate Professor of Neuroanatomy and Assistant Professor of Neurology, *Washington University School of Medicine St. Louis, Mo.**

OPPENHEIMER, JANE M., Ph.D., Assistant Professor of Biology, *Bryn Mawr College, Bryn Mawr, Pa.*

OSBORN, CLINTON M., B.A., M.A., Ph.D., Assistant Professor of Anatomy, *College of Medicine, Ohio State University, Columbus, O.**

OSTERUD, HJALMAR L., A.B., A.M., Ph.D., Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*

OVERHOLSER, MILTON D., A.B., A.M., Ph.D., M.D., Professor of Anatomy and Chairman of Department, *University of Missouri, Columbia, Mo.*

PAFF, GEORGE H., M.A., Ph.D., Associate Professor of Anatomy, *Long Island College of Medicine, 350 Henry St., Brooklyn, N. Y.*

PALMER, CARROLL E., M.A., Ph.D., M.D., Medical Officer in Charge, Office of Child Hygiene, *U. S. Public Health Service, Bethesda, Md.*

PALMER, DWIGHT M., B.Sc., M.Sc., M.D., Associate Professor of Anatomy and Neuro-psychiatry, *Ohio State University, Columbus, O.*

PANKRATZ, DAVID S., A.B., A.M., Ph.D., M.D., Professor of Anatomy, *University of Mississippi, Box 15, University, Miss.*

PAPANICOLAOU, GEORGE N., Ph.D., M.D., Associate Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

PAPEZ, JAMES WENCESLAS, B.A., M.D., Professor of Anatomy, *Cornell University, Ithaca, N. Y.*

Parker, Alice E., Ph.D., Instructor in Anatomy, *University of Colorado School of Medicine, Denver, Colo.*

Parker, George Howard, D.Sc., Professor of Zoology, Emeritus, *Harvard University, 16 Berkeley St., Cambridge, Mass.*

Parker, Raymond C., Ph.D., Research Associate, *Connaught Laboratories, University of Toronto, Toronto, Canada.*

Parkes, A. S., D.Sc., F.R.S., Member, *National Institute for Medical Research, Hampstead, London, N.W. 3, England.*

Patek, Paul R., B.A., Ph.D., Assistant Professor of Anatomy, *School of Medicine, University of Southern California, Los Angeles, Calif.*

Patten, Bradley Merrill, A.M., Ph.D. (Second Vice-Pres. '34–'36), Professor of Anatomy, *University of Michigan, Ann Arbor, Mich.*

Patterson, John Thomas, B.S., Ph.D., Professor of Zoology, *University of Texas, Austin, Tex.*

Pearson, Anthony A., M.A., Ph.D., Associate Professor of Anatomy, *Baylor University, College of Medicine, Houston 1, Tex.*

Peele, Talmage Lee, A.B., M.D., Associate in Anatomy, *Duke University Medical School, Durham, N. C.*

Pencharz, Richard I., Ph.D., Research Associate, Zoology Department, University of California, *Rancheria Rd., Kentfield, Calif.*

Perkins, Orman C., A.B., A.M., M.D., F.A.C.P., Professor of Neurology, Long Island College of Medicine, *829 Carroll St., Brooklyn, N. Y.**

Pfeiffer, Carroll A., Ph.D., Assistant Professor of Anatomy, *Yale University School of Medicine, 333 Cedar St., New Haven, Conn.*

Phelps, Doris H., A.B., M.A., Ph.D., Research Associate in Gynecology and Obstetrics, *Vanderbilt University School of Medicine, Nashville, Tenn.*

Piatt, Jean, B.S., M.A., Ph.D., Instructor in Anatomy, *School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

Pick, Joseph, M.D., Instructor in Anatomy, *New York University, College of Medicine, 477 First Ave., New York City.*

Piersol, William Hunter, B.A., M.B., Professor of Histology and Embryology, University of Toronto, *103 Hudson Drive, Toronto Canada.*

Pincus, Gregory, Sc.D., Visiting Professor of Experimental Zoology, *Clark University, Worcester, Mass.*

Plagge, James C., S.B., Ph.D., Department of Anatomy, College of Medicine, University of Illinois, 1853 W. Polk St., Chicago, Ill.

Pliske, Edward C., Ph.D., Instructor in Anatomy, *Medical School, University of North Carolina, Chapel Hill, N. C.*

Pohlman, Augustus G., M.D. (Ex. Com. '32–'36), Associate Clinical Professor of Otolarngology, University of Southern California, *4056 Farmouth Dr., Los Angeles 27, Calif.*

Polyak, Stephen, M.D., Professor of Anatomy, Department of Anatomy, *The University of Chicago, Chicago, Ill.*

Pomerat, Charles M., A.B., A.M., Ph.D., Professor of Anatomy, *University of Texas, Medical Branch, Galveston, Tex.*

Pomerat, Gerard Roland, A.B., A.M., Ph.D., Instructor in Biology, *Harvard University, Cambridge, Mass.*

POYNTER, CHARLES W. M., B.S., M.D., (Ex. Com. '19–'22), Professor of Anatomy, and Dean of the College of Medicine, University of Nebraska, *Forty-second and Dewey Ave., Omaha, Neb.*

PRATT, JEAN PAUL, M.D., Surgeon in Charge of Divisions of Gynecology and Obstetrics, *Henry Ford Hospital, Detroit, Mich.*

PRYOR, JOSEPH WILLIAM, M.D., Emeritus Professor of Anatomy and Physiology, University of Kentucky, *417 West Second St., Lexington, Ky.*

PUCKETT, WILLIAM O., M.A., Ph.D., Assistant Professor of Biology, *Princeton University, Princeton, N. J.*

QUIRING, D. P., M.A., Ph.D., Associate Professor of Biology, Western Reserve University; Head of Anatomy Division, Cleveland Clinic Foundation, *2249 Demington Dr., Cleveland Heights, O.*

RAMSAY, ANDREW J., Ph.D., Associate Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, 11th and Clinton Sts., Philadelphia, Pa.*

RASMUSSEN, ANDREW T., Ph.D., (Ex. Com. '34–'38), Professor of Neurology, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

RAVEN, HENRY C., Curator, Department of Comparative Anatomy, American Museum of Natural History; Associate in Zoology, Columbia University; *American Museum of Natural History, 77th St. and Central Park West, New York City 24.* Deceased.

RAWLES, MARY E., A.B., S.M., Ph.D., Research Associate (Embryology), *Department of Biology, Johns Hopkins University, Baltimore, Md.*

RAWLINSON, HERBERT E., M.D., M.Sc., Ph.D., Associate Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

REAGAN, FRANKLIN P., Ph.D., Lecturer in Anatomy, Hospitals Centre, Medical School, *The University, Edmund St., Birmingham, England.*

REECE, RALPH P., B.Sc., M.Sc., Ph.D., Assistant Professor of Dairy Husbandry, *New Jersey Agricultural Experiment Station, New Brunswick, N. J.*

REED, ADRIAN F., A.B., M.A., Ph.D., M.D., Associate Professor of Gross Anatomy, Tulane Medical School, *P.O. Sta. 20, New Orleans, La.*

REESE, JOHN D., M.D., Assistant Professor of Anatomy, *University of California, Berkeley, Calif.**

REINHARDT, WILLIAM O., A.B., M.D., Instructor and Assistant Professor of Anatomy, *University of California, Berkeley, Calif.*

REVELL, DANIEL GRAISBERRY, A.B., M.B., Professor Emeritus of Anatomy, University of Alberta, *9105 112 St., South Edmonton, Alberta, Canada.*

REYNOLDS, SAMUEL R. M., M.A., Ph.D., Research Associate, *Department of Embryology, Carnegie Institution of Washington, Wolfe and Madison Sts., Baltimore, Md.*

RHINEHART, D. A., A.M., M.D., Professor of Applied Anatomy, University of Arkansas, *4 Armistead Rd., Little Rock, Ark.*

RHINES, RUTH, B.S., M.S., Ph.D., Instructor in Anatomy, *Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

RICE, EDWARD LORANUS, A.B., Ph.D., Sc.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware, O.*

RICHARDSON, DOROTHY, A.B., Ph.D., Associate Professor of Zoology, *Connecticut College, New London, Conn.*

RICHTER, KENNETH M., B.A., M.A., Ph.D., Assistant Professor of Histology and Embryology, *University of Oklahoma, School of Medicine, Oklahoma City 4, Okla.*

RIENHOFF, WILLIAM F., JR., A.B., M.D., Associate Professor of Surgery, Johns Hopkins Hospital, *1201 North Calvert St., Baltimore, Md.*

RILEY, HENRY A., B.A., A.M., M.D., Professor of Clinical Neurology, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

RINGOEN, ADOLPH R., B.A., M.A., Ph.D., Professor of Zoology, *University of Minnesota, Minneapolis, Minn.*

RIOCH, DAVID MCK., M.D., Director of Research, Chestnut Lodge Sanitarium, *500 W. Montgomery Ave., Rockville, Md.*

RISLEY, PAUL L., B.A., M.S., Ph.D., Associate Professor of Zoology, *State University of Iowa, Iowa City, Ia.*

ROBERTS, JOSEPH THOMAS, B.A., M.S., M.D., Ph.D., Chief Medical Officer, Gallinger Municipal Hospital; Adjunct Clinical Professor of Medicine, Schools of Medicine of Georgetown University and George Washington University; *Gallinger Municipal Hospital, 19th St. and Massachusetts Ave., S. E., Washington, D. C.*

ROBERTSON, GEORGE GORDON, B.A., B.Sc., Ph.D., Instructor in Anatomy, *Baylor University, College of Medicine, Houston 1, Tex.*

ROBINSON, BYRON L., A.B., M.A., M.D., Dean and Professor of Anatomy, *University of Arkansas Medical School, Little Rock, Ark.*

ROGERS, JAMES B., A.M., M.D., Professor of Anatomy, *University of Louisville, School of Medicine, 101 W. Chestnut, Louisville, Ky.*

ROGERS, PHILIP V., Ph.D., Assistant Professor of Biology, *Hamilton College, Clinton, N. Y.*

ROGERS, WILLIAM MITCHELL, B.S., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

ROMER, ALFRED S., B.A., Ph.D., Professor of Zoölogy and Curator of Vertebrate Palaentology, *Biological Laboratories, Harvard University, Cambridge, Mass.*

RONCORONI, ENRIQUE J., M.D., Professor of Anatomy, *Universidad del Litoral. Rosario, Republic of Argentina.*

RONSTROM, G. N., M.D., Assistant Professor of Anatomy, *Louisiana State University Medical Center, 1542 Tulane Ave., New Orleans, La.*

ROOFE, PAUL GIBBONS, B.S., Ph.D., Assistant Professor of Anatomy, *University of Louisville, School of Medicine, Louisville, Ky.*

ROSSMAN, ISADORE, A.B., Ph.D., *383 Springfield Ave., Newark 3, N. J.**

RUBINSTEIN, HYMAN S., M.D., Ph.D., Consultant in Psychiatry, U. S. Public Health Service; Director Research Laboratory, Surgical Division, Sinai Hospital, *2349 Eutaw Pl., Baltimore, Md.*

RUDNICK, DOROTHEA, Ph.B., Ph.D., Assistant Professor of Biology, *Albertus Magnus College, 700 Prospect St., New Haven, Conn.*

RUGH, ROBERTS, B.A., M.A., Ph.D., Associate Professor of Biology, New York University, *110 Morningside Drive, New York City.*

RUTH, EDWARD S., M.D., F.A.C.S., *1680 North Vine St., Hollywood, Calif.*

RUTH, ELBERT B., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *College of Medicine, Eden Ave., University of Cincinnati, Cincinnati, O.*

Sabin, Florence R. B.S., M.D., Sc.D., LL.D. (Second Vice-Pres. '08–'09, Pres. '24–'26), Member Emeritus of Rockefeller Institute for Medical Research, 66th St. and York Ave., New York City; *1333 East 10th Ave., Denver, Colo.*

Salmon, Theodora N., B.A., M.A., Ph.D., Instructor, Department of Biological Sciences, Hunter College; Research Associate, Columbia University, *19 Essex Ave., Montclair, N. J.*

Salsbury, C. R., M.D., C.M., F.R.C.S.(C.), F.R.C.S.(Eng.), Assistant Professor of Anatomy and Curator of Surgical Pathology, *Queen's University, Kingston, Ontario, Canada.**

Sandstrom, Carl J., Ph.D., Associate Professor of Biology, *New York University, New York City.*

Sattler, Dwight G., M.D., Instructor in Anatomy, *State University of Iowa, College of Medicine, Iowa City, Ia.**

Sauer, Mary E., A.B., A.M., Ph.D., Assistant Professor of Anatomy, University of Texas, *1115 Ave. E., Galveston, Tex.*

Saunders, John S. deC. M., M.B., Ch.B., F.R.C.S., Professor of Anatomy, Chairman of Division of Anatomy, *University of California, Berkeley, Calif.*

Saunders, Richard L. de C. H., M.B.Ch.B., M.D., Associate Professor of Anatomy, *Dalhousie University, Halifax, Nova Scotia, Canada.*

Sawin, Paul B., Sc.D., Assistant Professor of Biology, *Arnold Laboratory, Brown University, Providence, R. I.*

Sawyer, Charles H., A.B., Ph.D., Associate in Anatomy, *Duke University School of Medicine, Durham, N. C.*

Scammon, Richard E., Ph.D., LL.D. (Ex. Com. '23–'26, '35–'39, Vice-Pres. '28–'30), Distinguished Service Professor in the Graduate School, *University of Minnesota, Minneapolis, Minn.*

Schadewald, Melvin, B.S., M.S., Ph.D., Instructor in Anatomy, *Medical College of the State of South Carolina, Charleston, S. C.**

Schaeffer, Bobb, A.B., A.M., Ph.D., Associate in Histology and Embryology, *Jefferson Medical College, Daniel Baugh Institute of Anatomy, 307 S. Eleventh St., Philadelphia 7, Pa.**

Schaeffer, Jacob Parsons, A.M., M.D., Ph.D., Sc. D. (Ex. Com. '24–'29, Vice-Pres. '42–'43; Acting Pres. '43–), Professor of Anatomy and Director of the Daniel Baugh Institute of Anatomy, Jefferson Medical College, *4634 Spruce St., Philadelphia, Pa.*

Scharrer, Ernst, M.D., Ph.D., Assistant Professor of Anatomy, *School of Medicine, Western Reserve University, 2109 Adelbert Rd., Cleveland, O.*

Schmidt, Ida Genther, B.A., M.A., Ph.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, O.*

Schoemaker, Daniel M., B.S., M.D., Professor of Anatomy, School of Medicine, St. Louis University, *1402 S. Grand Ave., St. Louis, Mo.*

Schooley, J. P., Ph.D., Director, Endocrine Laboratories, *Difco Laboratories, Inc., Detroit, Mich.*

Schotté, Oscar E., Lic. Sc. Phys. et Nat., Doct. Sc. Nat., Geneva, Switzerland, Associate Professor of Biology, *Amherst College, Amherst, Mass.*

Schour, Isaac, B.S., D.D.S., M.S., Ph.D., Professor of Histology and Head of the Department, University of Illinois College of Dentistry, *808 South Wood St., Chicago, Ill.*

SCHULTZ, ADOLPH H., Ph.D., Associate Professor of Physical Anthropology, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

SCHWARTZ, HENRY G., M.D., Instructor in Neurological Surgery, Washington University Medical School, *Barnes Hospital, St. Louis, Mo.**

SCHWEIZER, MALVINA, Ph.D., Instructor in Biology, Washington Square College, New York University, *50 West 67th St., New York City.*

SCHWIND, JOSEPH L., A.B., A.M., Ph.D., Associate Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

SCOTT, GORDON H., Ph.D., Professor and Head of Department of Anatomy, *University of Southern California School of Medicine, 3551 University Ave., Los Angeles, Calif.*

SCOTT, JOHN W., A.M., Ph.D., Professor of Zoology and Research Parasitologist, University of Wyoming, *1409 Garfield St., Laramie, Wyo.*

SEDWICK, H. JOBE, D.D.S., *913 18th St., Newport News, Va.**

SEIB, GEORGE A., A.B., M.D., Assistant Professor of Anatomy, Washington University, *2323 Lafayette Ave., St. Louis, Mo.*

SELLING, LAURENCE, A.B., M.D., Professor of Medicine, University of Oregon Medical School, *6005 S. W. Hamilton St., Portland, Ore.*

SELYE, HANS, M.D., Ph.D., D.Sc., F.R.S.(C), Associate Professor of Histology, *Department of Anatomy, McGill University, Montreal, Canada.*

SENSENIG, E. CARL, B.A., M.S., Ph.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

SEVERINGHAUS, AURA E., B.S., M.A., Ph.D., Assistant Dean and Associate Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

SHANER, RALPH FAUST, Ph.D., Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

SHANKLIN, WILLIAM M., Ph.D., Professor of Histology and Neuroanatomy, *American University of Beirut, Beirut, Syria.*

SHAPIRO, HARRY H., D.M.D., Assistant Professor of Anatomy, *Columbia University, 630 West 168th St., New York City.*

SHARP, CLAYTON, M.D., Assistant Professor of Anatomy, *Long Island College of Medicine, 350 Henry St., Brooklyn, N. Y.*

SHEEHAN, DONAL, M.D., D.Sc., M.R.C.S., Professor of Anatomy and Director of the Anatomical Laboratories, *New York University, College of Medicine, 477 First Ave., New York City.*

SHEININ, JOHN J., B.S., M.S., Ph.D., M.B., Dean and Chairman Department of Anatomy, *Chicago Medical School, 710 South Wolcott Ave., Chicago, Ill.*

SHIELDS, RANDOLPH TUCKER, A.B., M.D., *Department of Pathology, University of North Carolina School of Medicine, Chapel Hill, N. C.*

SHRYOCK, EDWIN H., B.S., M.A., M.D., Assistant Professor of Anatomy, *College of Medical Evangelists, Loma Linda, Calif.*

SHUMWAY, WALDO, A.B., A.M., Ph.D., Professor of Zoölogy, *University of Illinois, Urbana, Ill.**

SIMER, PARKE H., B.Ed., M.A., Ph.D., Associate Professor of Anatomy, *University of Illinois, 1853 W. Polk St., Chicago, Ill.*

SIMKINS, CLEVELAND S., A.B., Ph.D., Head, Department of Anatomy, *Creighton Medical School, Omaha, Neb.*

SIMPSON, MIRIAM ELIZABETH, A.B., M.A., Ph.D., M.D., Associate Professor of Anatomy, *University of California, Berkeley, Calif.*

SIMPSON, WILLIAM L., B.S., Ph.D., Research Associate, Department of Anatomy, Washington University and The Barnard Free Skin and Cancer Hospital, *Washington University, St. Louis, Mo.*

SINCLAIR, JOHN G., B.S., M.S., Ph.D., Acting Chairman, Department of Anatomy, and Professor of Histology-Embryology, *University of Texas, Medical Branch, Galveston, Tex.*

SINGER, EDWARD, M.D., Associate Director, St. Clare's Hospital, *133 East 58th St., New York City.*

SINGER, MARCUS, B.S., A.M., Ph.D., Instructor in Anatomy, *Harvard Medical School, Boston, Mass.*

SMELSER, GEORGE K., Ph.D., Assistant Professor of Anatomy, *Columbia University, College of Physicians and Surgeons, 630 West 168th St., New York City.*

SMITH, BERTRAM GARNER, A.B., Ph.D., *R.R. no. 2, Box 50, Albuquerque, N. M.*

SMITH, CARLTON G., B.A., M.Sc., M.D., Ph.D., Assistant Professor of Anatomy, *University of Toronto, Toronto 5, Canada.**

SMITH, CHRISTIANNA, A.M., Ph.D., Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

SMITH, DAVID T., A.B., M.D., Associate Professor of Medicine and Professor of Bacteriology, Duke University, *Duke Hospital, Durham, N. C.*

SMITH, GEORGE MILTON, A.B., M.D., Research Associate in Anatomy, Yale University School of Medicine, *Pine Orchard, Conn.*

SMITH, PHILIP EDWARD, M.S., Ph.D. (Ex. Com. '34–'38), (Pres. '40–'42), Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *632 West 168th St., New York City.*

SMITH, WILBUR CLEVELAND, B.A., M.D., Sc.D., Head of the Department of Gross Anatomy, *Tulane University, New Orleans, La.*

SMITH, WILBUR K., A.B., M.D., Associate Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*

SNIDER, RAY S., Ph.D., Instructor in Physiology, *The Johns Hopkins University, School of Medicine, Baltimore, Md.*

SNODGRASS, L. E., A.B., M.D., Instructor in Surgery, Medical Department, University of Pennsylvania, *7903 Oxford Ave., Philadelphia, Pa.*

SNOOK, THEODORE, Ph.D., Assistant Professor of Anatomy, *Syracuse University, College of Medicine, Syracuse, N. Y.*

SNYDER, FRANKLIN FAUST, M.D., Associate Professor of Anatomy and Obstetrics, *Harvard Medical School, 25 Shattuck St., Boston, Mass.*

SOLNITZKY, OTHMAR, A.B., A.M., Ph.D., M.D., Professor and Director of the Department of Anatomy, Georgetown University, School of Medicine; Director, Georgetown University Brain Research Institute, *3900 Reservoir Rd., Washington, D. C.*

SPECTOR, BENJAMIN, M.D., Professor of Anatomy, *Tufts College Medical School, 416 Huntington Ave., Boston, Mass.*

SPEIDEL, CARL CASKEY, Ph.B., Ph.D., Sc.D. (Ex. Com. '40–), Professor of Anatomy, *Medical Department, University of Virginia, Charlottesville, Va.*

SPRAGUE, JAMES MATHER, A.B., A.M., Ph.D., Assistant in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

STARK, MARY B., Ph.B., M.A., Ph.D., Sc.D., Professor of Histology and Embryology, *New York Medical College and Flower Hospital, Fifth Ave. and 105th St., New York City.*

STEIN, KATHRYN F., M.S., Ph.D., Assistant Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

STEVENSON, PAUL HUSTON, B.S., M.A., M.D., Dr.P.H. Formerly Associate Professor of Anatomy, Peiping Union Medical College, Peiping, China, *6210 York Rd., Baltimore, Md.**

STILES, HENRY WILSON, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *R.D. no. 2, Mt. Kisco, N. Y.*

STILWELL, E. FRANCES, A.B., A.M., Ph.D., Associate Professor of Anatomy, *Woman's Medical College of Pennsylvania, Philadelphia, Pa.*

STONE, LEON STANSFIELD, Ph.B., Ph.D., Bronson Professor of Comparative Anatomy, *Yale University School of Medicine, 333 Cedar St., New Haven, Conn.*

STOPFORD, JOHN SEBASTIAN B., M.D., Sc.D., D.Sc., F.R.S., Vice-Chancellor and Professor of Experimental Neurology, *University of Manchester, Manchester, England.*

STOWELL, ROBERT E., A.B., M.D., Ph.D., Assistant in Pathology, Washington University School of Medicine; Assistant Resident in Pathology, Barnes Hospital; Research Associate, Barnard Free Skin and Cancer Hospital, *Department of Pathology, Washington University School of Medicine, St. Louis, Mo.*

STRAUS, WILLIAM L., JR., A.B., Ph.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore 5, Md.*

STREETER, GEORGE L., A.M., M.D., Sc.D., LL.D., (Ex. Com. '18–'20, Pres. '26–'28), Research Associate, *Carnegie Institution of Washington, Johns Hopkins Medical School, 710 N. Washington St., Baltimore, Md.*

STRÖER, W. F. H., Ph.D., Prosector in Anatomy, *University of Groningen, Groningen, Holland.*

STROMSTEN, FRANK ALBERT, B.S., M.S., D.Sc., Associate Professor of Zoölogy, State University of Iowa, *318 Zoology Building, Iowa City, Ia.*

STRONG, LEON H., A.B., B.S., Ph.D., Assistant Professor of Anatomy, Medical School, University of Michigan, *4502 E. Medical Building, University of Michigan, Ann Arbor, Mich.*

STRONG, OLIVER S., A.B., A.M., Ph.D., Professor Emeritus of Neurology and Neurohistology, Columbia University, *Box 536, Woods Hole, Mass.*

STRONG, REUBEN MYRON, A.B., A.M., Ph.D. (Ex. Com. '16–'19), Professor of Anatomy, *Loyola University School of Medicine, 706 South Wolcott Ave., Chicago, Ill.*

STULTZ, WALTER A., B.A., Ph.D., Associate Professor of Anatomy, *University of Vermont, College of Medicine, Burlington, Vt.*

STUNKARD, H. W., B.S., A.M., Ph.D., Sc.D., Professor of Biology, *New York University, University Heights, New York City.*

SULLIVAN, WALTER EDWARD, A.M., Ph.D. (Ex. Com. '41–), Professor of Anatomy, University of Wisconsin, *Science Hall, Madison, Wis.*

SUMMERS, FRANCIS M., Ph.D., Instructor in Biology, *College of the City of New York, 139th St. and Convent Ave., New York City.*

SWANK, ROY LAVER, Ph.D., M.D.*

SWENSON, E. A., A.B., A.M., Ph.D.

SWIFT, CHARLES H., M.D., Ph.D., Associate Professor of Anatomy, *The University of Chicago, Chicago, Ill.*

SWINGLE, W. W., A.B., A.M., Ph.D., Professor of Biology, *Princeton University, Princeton, N. J.*

SWINYARD, C. A., M.S., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Utah, Salt Lake City, Utah.*

SYKES, GEORGE F., Ph.B., M.A., Assistant Professor of Anatomy, Tufts College Medical School, *416 Huntington Ave, Boston, Mass.*

TEITELBAUM, HARRY A., B.S., M.D., Ph.D., Assistant in Neurology, The Johns Hopkins University Medical School; Assistant in Neurology and Instructor in Anatomy, University of Maryland School of Medicine, *1411 Eutaw Pl., Baltimore, Md.**

TERNI, TULLIO, M.D., Professor of Anatomy, *The University of Padua, Padua, Italy.*

TERRILL, CLAIR ELMAN, B.S., Ph.D., Animal Husbandman (Physiologist and Geneticist), *U. S. Western Sheep Breeding Laboratory, Dubois, Idaho.*

TERRY, ROBERT JAMES. A.B., M.D. (Ex. Com. '08–'12, '21–'24), Professor of Anatomy, Emeritus, *Washington University School of Medicine, St. Louis, Mo.*

THARALDSEN, CONRAD E., B.S., M.A., Ph.D., Professor of Anatomy, *New York Medical College, 1 East 105th St., New York City.* Deceased.

THOMPSON, IAN MACLAREN, B.Sc., M.B., Ch.B., Professor of Anatomy and Director of the Department of Anatomy, *Medical College, University of Manitoba, Winnipeg, Canada.*

THOMSON, STEWART CRAIG, A.B., M.S., M.D., Assistant Professor of Anatomy, Assistant Dean, *Loyola University School of Medicine, 706 S. Wolcott Ave., Chicago, Ill.**

THORKELSON, JACOB, M.D., Member of Congress; MC-V (S) USNR, *National Hotel, Butte, Mont.*

THURINGER, JOSEPH M., M.D., Professor of Histology and Embryology, University of Oklahoma, School of Medicine, *801 N. E. 13th St., Oklahoma City, Okla.*

TOBIN, CHARLES E., Ph.D., Assistant Professor of Anatomy, *The University of Rochester, School of Medicine and Dentistry, 260 Crittenden Blvd., Rochester, N. Y.*

TOMPKINS, EDNA H., M.D., Associate Professor of Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

TOWER, SARAH SHELDON, B.S., Ph.D., M.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

TRACY, HENRY C., A.B., A.M., Ph.D., Professor of Anatomy, *University of Kansas, Lawrence, Kan.*

TROTTER, MILDRED, A.B., M.S., Ph.D., Associate Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

TRUEX, RAYMOND C., M.S., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

TURNER, CHARLES W., B.S., A.M., Ph.D., Professor of Dairy Husbandry, *University of Missouri, Columbia, Mo.*

TURNER, C. DONNELL, Ph.D., Assistant Professor of Zoology, *Northwestern University, 105 Locy Hall, Evanston, Ill.*

TURNER, CLARENCE L., M.A., Ph.D., Professor of Zoology, *Northwestern University, Evanston, Ill.*

TURNER, ROBERT S., A.B., Ph.D., Assistant Professor of Anatomy, *Stanford University, Stanford University, Calif.*

UHLENHUTH, EDUARD, Ph.D., Professor of Anatomy, *University of Maryland Medical School, Baltimore, Md.*

UOTILA, UNTO U., M.D., Research Fellow in Anatomy, Harvard Medical School, Boston, Mass. (1939); Docent in Microscopical Anatomy, *Helsinki University, Siltavuorenpenger 20, Helsinki, Finland.*

VAN CAMPENHOUT, ERNEST, M.D., Ph.D., Professor of Anatomy, Histology and Embryology, *Université de Louvain, Louvain, Belgium.*

VAN CLEAVE, C. D., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of North Carolina, Chapel Hill, N. C.*

VAN DER HORST, C. J., D.Sc., Professor, Head of the Department of Zoölogy, *University of the Witwatersrand, Johannesburg, So. Africa.*

VAN DYKE, JOHN H., A.B., M.S., Ph.D., Instructor in Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

VAN WAGENEN, GERTRUDE, A.B., Ph.D., Research Associate in Obstetrics and Gynecology, Associate Professor's rank, Yale University, *New Haven Hospital, New Haven, Conn.*

VENABLE, JOHN HEINZ, B.S., M.D., Assistant Professor of Anatomy, *Emory University, Emory, Ga.*

VICARI, EMELIA, A.B., A.M., Research Fellow, *Roscoe B. Jackson Laboratory, Bar Harbor, Me.*

VON BONIN, GERHARDT, M.D., Professor of Anatomy, University of Illinois, College of Medicine, *1853 West Polk St., Chicago, Ill.*

VONDERAHE, A. R., A.B., B.Sc., M.D., Associate Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, O.*

WAITE, FREDERICK CLAYTON, A.M., Ph.D., Emeritus Professor of Histology and Embryology, Western Reserve University School of Medicine, *144 Locust St., Dover, N. H.*

WALLER, WILLIAM H., Ph.D., Professor of Anatomy, *University of South Dakota, Medical School, Vermillion, S. Dak.*

WALLIN, IVAN E., M.A., D.Sc., Professor of Anatomy and Head of Department, *Secretary of Faculty, University of Colorado, School of Medicine, Denver, Colo.*

WALLS, G. L., Sc.D., *Scientific Bureau, Bausch and Lomb Optical Co., Rochester, N. Y.*

WALMSLEY, THOMAS, M.D., F.R.S.E., Professor of Anatomy, *Queen's University of Belfast, Belfast, Ireland.*

WARBRITTON, VIRGENE, Ph.D., (Mrs. Fred Kavanagh), Research worker, New Jersey Agricultural Experiment Station, *1001 Georges Rd., New Brunswick, N. J.*

WARD, JAMES W., Ph.D., M.D., Assistant Professor of Anatomy, Vanderbilt University Medical School, *Vanderbilt Hospital, Nashville, Tenn.*

WARREN, A. EMERSON, B.A., Ph.D., Professor of Zoology, *McMaster University, Hamilton, Ontario, Canada.*

WARREN, CHARLES O., A.B., Ph.D., M.D., Assistant Professor of Anatomy and Physiology, *Cornell University Medical College, 1300 York Ave., New York City.*

WASHBURN, SHERWOOD L., A.B., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

WASSERMANN, FRIEDRICH, M.D., Associate Professor of Anatomy, *The University of Chicago, Chicago, Ill.*

WATERMAN, ALLYN J., A.B., A.M., Ph.D., Associate Professor of Biology, *Williams College, Williamstown, Mass.*

WATKINS, RICHARD WATKIN, S.B., M.D., Assistant Professor of Otolaryngology, Rush Medical College, *5608 Kenwood Ave., Chicago, Ill.*

WATT, JAMES CRAWFORD, M.A., M.D., Professor of Anatomy, *University of Toronto, Toronto, Canada.*

WEATHERFORD, HAROLD LORRAINE, A.B., A.M., Ph.D., Assistant Professor of Anatomy, *Harvard Medical School, Boston, Mass.*

WEAVER, HARRY M., A.B., M.S., Ph.D., Acting Chairman, *Department of Anatomy, Wayne University College of Medicine, Detroit, Mich.*

WEBB, RICHARD L., A.B., M.S., Ph.D., Associate Professor of Anatomy, *College of Medicine, University of Illinois, 1853 W. Polk St., Chicago, Ill.*

WEED, LEWIS HILL, A.B., A.M., M.D., Sc.D., LL.D. (Ex. Com. '20–21, '35–'39, Sec.-Treas. '22–'30), Professor of Anatomy and Director, *Johns Hopkins Medical School, Baltimore, Md.*

WEICHERT, CHARLES KIPP, B.S., M.S., Ph.D., Professor of Zoology, *University of Cincinnati, Cincinnati 21, O.*

WEIDENREICH, FRANZ, Dr. Med., Honorary Director, Cenozoic Laboratory, Peiping Union Medical College, Peking, China, *American Museum of Natural History, New York City.*

WEINSTEIN, BENJAMIN B., B.S., M.D., M.S., Instructor in Gross Anatomy and Gynecology, Tulane University of Louisiana, *300 Medical Arts Building, New Orleans, La.*

WEISS, PAUL ALFRED, Ph.D., Professor of Zoology, *The University of Chicago, Chicago, Ill.*

WEISSENBERG, RICHARD, M.D., Professor of Histology and Embryology, *School of Medicine, Middlesex University, Waltham, Mass.*

WELLS, LEMEN J., A.M., Ph.D., Associate Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

WESTON, JEAN K., M.S., Ph.D., M.D., Professor of Anatomy, Temple University School of Medicine, *Broad at Ontario St., Philadelphia, Pa.*

WHEELER, THEODORA, A.B., M.D., Clinical Associate in Neurology, *Rush Medical College, 1758 W. Harrison St., Chicago, Ill.*

WHITAKER, WAYNE L., A.B., A.M., Ph.D., Instructor in Anatomy, *University of Michigan, Ann Arbor, Mich.*

WHITESIDE-HARVEL, BEATRICE, B.A., Ph.D., Voluntary Research Worker, *c/o Guaranty Trust Co., 140 Broadway, New York City.*

WIEMAN, H. L., Ph.D., Professor of Zoology, *University of Cincinnati, Cincinnati, O.*

WIERDA, JAY L., Ph.D., Assistant Professor of Anatomy, *School of Medicine, University of Pennsylvania, Philadelphia, Pa.*

WILLARD, WILLIAM A., A.M., Ph.D., Professor of Anatomy, University of Nebraska, *College of Medicine, Forty-second St. and Dewey Ave., Omaha, Neb.*

WILLIAMS, GEORGE DEE, A.B., A.M., M.D., Ph.D., Assistant Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.**

WILLIAMS, ROY GRIFFIN, A.M., M.D., Associate Professor of Anatomy, *University of Pennsylvania School of Medicine, Philadelphia, Pa.*

WILLIAMS, STEPHEN CULVER, Ph.D., Assistant Professor of Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

WILLIAMS, W. LANE, B.S., M.A., Ph.D., Assistant Professor of Anatomy, *School of Medicine, Louisiana State University, New Orleans 13, La.*

WILLIER, BENJAMIN HARRISON, B.S., Ph.D., D.Sc., Henry Walters Professor of Zoology and Chairman of Department of Biology, *Johns Hopkins University, Charles and 34th Sts., Baltimore, Md.*

WILSON, JAMES G., B.A., M.A., Ph.D., Instructor in Anatomy, *The University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

WILSON, JAMES THOMAS, M.A., M.B., LL.D., F.R.S., Emeritus Professor of Anatomy, *University of Cambridge, 24 Millington Road, Cambridge, England.*

WINDLE, WILLIAM F., B.S., M.S., Ph.D., Professor of Neurology and Director of the Institute of Neurology, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

WISLOCKI, GEORGE B., A.B., M.D., A.M. (hon.), (Ex. Com. '37–'41), James Stillman Professor of Comparative Anatomy, *Harvard Medical School, Boston, Mass.*

WITSCHI, EMIL, Ph.D., Professor of Zoology, *State University of Iowa, Iowa City, Ia.*

WOERNER, CHARLES A., B.S., Ph.D., Instructor in Anatomy, *New York Medical College, 1 East 105th St., New York City.*

WOLFE, J. M., Ph.D., Associate Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

WOODBURNE, RUSSELL T., M.A., Ph.D., Assistant Professor of Anatomy, *University of Michigan, Ann Arbor, Mich.*

WOODMAN, ALICE S., M.D., Associate Professor of Histology and Embryology, *Boston University School of Medicine, 80 East Concord St., Boston, Mass.*

WORCESTER, JOHN LOCKE, M.D., Professor of Anatomy, University of Washington, *5211 Twenty-first Ave., N. E., Seattle, Wash.*

WRIGHT, WALTER H., D.D.S., B.S., M.S., Ph.D., Professor of Anatomy and Prosthetic Dentistry, School of Dentistry, University of Pittsburgh, *1306 Penn Ave., Wilkinsburg Sta., Pittsburgh, Pa.*

YEAKEL, ELEANOR H., A.B., M.A., Ph.D., Fellow, *Wistar Institute of Anatomy and Biology, Philadelphia, Pa.*

YNTEMA, C. L., Ph.D., Assistant Professor of Anatomy, *Cornell University Medical College, New York City.*

YOFFEY, J. M., M.Sc., M.D., F.R.C.S., Professor of Anatomy, *The University, Bristol, Great Britain.*

YOUNG, M. WHARTON, M.D., Ph.D., Associate Professor of Anatomy, *Howard University, Washington, D. C.*

YOUNG, WILLIAM C., Ph.D., Associate Professor of Primate Biology, *Yale Laboratories of Primate Biology, Orange Park, Fla.*

YOUNGSTROM, KARL A., Ph.D., Associate in Anatomy, Duke University School of Medicine, *Duke Station, Box 3608, Durham, N. C.*

ZACHARIAS, LEONA RUTH, B.A., M.A., Ph.D., Instructor in Anatomy, *Columbia University, College of Physicians and Surgeons, New York City.*

ZECHEL, GUSTAV, M.D., F.A.C.S., Assistant Professor in Anatomy, and Associate in Surgery, University of Illinois College of Medicine, *1853 W. Polk St., Chicago, Ill.*

ZEIT, WALTER, B.S., M.S., Ph.D., Associate Professor of Anatomy, *Marquette University School of Medicine, 561 North 15th St., Milwaukee 3, Wis.*

ZIMMERMANN, ARNOLD, Lic.Sc., D.Sc. (Geneva, Switzerland), Professor of Anatomy, University of Illinois College of Medicine, *1853 W. Polk St., Chicago, Ill.*

ZWEIFACH, BENJAMIN WILLIAM, B.S., M.S., Ph.D. Research Associate in Biology, *New York University, New York City.*

ZWEMER, RAYMUND L., A.B., Ph.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *630 West 168th St., New York City.*

THE GUINEA-PIG SPLEEN. STUDIES ON THE STRUCTURE AND CONNECTIONS OF THE VENOUS SINUSES[1]

THEODORE SNOOK

Department of Anatomy, College of Medicine, Syracuse University, New York

THREE PLATES (TWENTY-NINE FIGURES)

INTRODUCTION

Following the publication of Knisley's ('36) observations on the circulation through the transilluminated living spleen, many anatomists believed that some of the spleen's more closely guarded secrets had finally succumbed to a century of active probing. Knisley's diagram of a typical system of arteries, sinuses and collecting vein is too well known to require comment. In their extensive series of similar transillumination studies, MacKenzie and others ('41) were unable to confirm the majority of Knisley's findings. The two sets of results were quite contradictory, and one naturally wonders wherein lies the explanation for such radical disagreement. The relative optical efficiency and injury factors of their respective equipment are difficult to evaluate. The choice of experimental animals does offer a partial explanation for the confusion existing in the field in general as well as for the contradictions between the papers in question.

Knisley listed 75 white mice, 30 white rats and 15 cats as experimental subjects. MacKenzie et al. used 210 white mice, 12 white rats, 6 rabbits, 8 guinea-pigs and 13 cats. That there are at least two basic types of red pulp architecture is implied by Robinson ('30) in his discussion of the venous drainage of the cat's spleen. In the cat he found that arterial and venous systems were entirely independent, the veins beginning de novo in the pulp and that venous sinuses are lacking. In contrast to the cat he states, "In the human, sheep, ox, rabbit, guinea-pig and dog spleens, one finds a very extensive system of venous capillaries (sinuses) which, particularly in the human, almost overshadow the pulp." Preliminary studies indicate that the mouse belongs in the cat group and the rat in the human group.

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In one point Knisley and MacKenzie et al. do agree, and that is, to quote Knisley, ''No significant differences have yet been observed between the structure and activities of living mouse, rat and cat spleens.'' The guinea-pig and rabbit could be added from MacKenzie's account. Their respective views concerning the splenic circulation can best be quoted. Knisley ('36) concluded that, ''— the vascular system consists of a series of completely interconnected, preformed, lined channels.'' MacKenzie et al. ('41) stated that, ''The interstices of the pulp provide the one and only type of connection that we have seen to link arterial and venous systems.''

Another bone of contention is just what constitutes a venous sinus. According to Knisley, ''The venous sinuses are seen to be definite anatomical units, shaped roughly like sweet potatoes or like cucumbers. They penetrate the tissue in all directions each like a short, narrow-ended tunnel drilled in a cheese.'' MacKenzie et al. define the sinus as a ''rather short, slim twig on the venous tree.'' The former definition admirably fits the conditions found in guinea-pig (to be described later), and the latter, the cat and mouse. If one disregards Robinson's opinion, then these two groups would seem to represent extreme conditions in the degree of venous sinus elaboration; otherwise we would be dealing with sinused versus non-sinused spleens.

Since the transillumination studies on living spleens have been inconclusive, other methods of investigation are indicated. In a series of lectures on the spleen, McNee ('31) stated that, ''— an obstacle to progress had been a poor general knowledge of essential structure.'' It is the writer's contention that each species should be a study unto itself and that the ''essential structure'' should be worked out by a variety of methods before studies on the living organ are attempted. The results of such a study on the guinea-pig are recorded on the succeeding pages. The guinea-pig was chosen because of the similarity of its spleen to the human spleen.

MATERIALS AND METHODS

Spleens from newborn, young and adult guinea-pigs were used, the latter being the most satisfactory. They were quickly removed from freshly stunned and bled animals or from animals under chloroform, ether or sodium pentabarbitol anesthesia. The fixation employed was 10% formalin, Zenker-acetic or Zenker-formol. Serial paraffin sections were made from a portion of each spleen. A few frozen sections were also prepared. It was found that certain of the more recent modifications of the Bielschowsky silver impregnation technique for recticular fibers gave exceptionally clear pictures of the splenic vascular pattern (Wilder, '35, Gordon and Sweets, '36). These methods and others have been summarized and enlarged upon by Gomori ('40). Various methods of preparing the ammoniacal silver bath were tried, but the best results were obtained by following the directions given by Kubie and Davidson ('28). Briefly, the procedure is as follows. Firmly attached sections are deparaffinated, reinforced by a celloiden film, and brought to water. The slides are then taken through the following steps: acidified (H_2SO_4) 1% $KMnO_4$ — 1 min.; wash; 5% oxalic acid until clear (5 min.); wash; 2% ferric alum — 1 min. (or longer) or 1% uranium nitrate — 2 seconds; wash briefly in distilled water; silver ammonium hydroxide — 1 min. or silver ammonium carbonate — 10 min. (see Kubie and Davidson, '28); rinse quickly in distilled water; 1% formalin — 1 min.; wash; 0.2% gold chloride — 1 min.; wash; 5% "hypo" — 5 min.; wash; picrofuchsin (van Gieson) — ½ min.; dehydrate, clear and mount. Four trial slides should precede the serial sections to determine which of the alternate solutions gives the clearest results with that particular specimen. Hematoxylin, carmine and other stains may be used after the "hypo" has been washed out. The above method usually impregnates the finest ramifications of the splenic reticulum. Cells are practically colorless (unless counterstained) so do not obscure the picture. The sinuses, arteries and veins all stand out clearly. The great advantage of this approach is that distortion caused by perfusion or colored injection masses is avoided.

Because of the clarity of the pulp details and the ease with which they could be followed from section to section, reconstructions were possible. Reconstructions have been used by several investigators to demonstrate certain features of splenic structure. Hartmann and Bennett ('27) modelled the capsule and trabecular system of the human spleen; Hellsten ('28) reconstructed the lymphatic sheaths and nodules of the human; Jäger ('39) modelled the arterial system within and adjacent to the Malpighian corpuscle and Koboth ('39) reconstructed the reticulum from a small area of human spleen.

It was felt that a reconstruction of a small portion of the guinea-pig spleen on a large enough scale to show the shape, connections and relationships of the sinuses would be helpful in the present study. The region selected for reconstruction was subjacent to a vertical capsular surface and included a peripheral Malpighian corpuscle, several small trabeculae and an area of red pulp. The series was cut at 10 μ and the model area enlarged 200 ×. Tracings were made on 2 mm. wax plates. In cutting, the intersinusoidal areas (pulp cords) and the perinodular marginal zone were removed, leaving as solid wax the sinuses, capsule, trabeculae, lymphatic sheaths and nodule, arteries and veins. The model consists of 21 sections. It therefore stands 42 mm. in height. Its other dimensions are 150 mm. each. The model thus represents a reconstructed block of splenic tissue 210 μ by 750 μ by 750 μ. After the supporting bridges were removed, arterial branches were colored red and trabeculae crosshatched to facilitate tracing their course and distribution. Following the final smoothing process, the white pulp was carefully loosened from the glass plate and withdrawn intact from the red pulp portion of the model. Two stages of construction are shown in figures 1 and 3, and the sections from which the uppermost plates were cut are shown in figures 2 and 5 respectively. The isolated white pulp is shown in figure 6, and a view into the concavity which it filled is shown in figure 9. Figures 7 and 8 are views from the top and bottom of the model, as seen in figure 3, respectively.

OBSERVATIONS AND DISCUSSION

Venous sinuses. Examination of the photographs of the various views of the model show that the sinuses are very real structures, and that they form an intricate system of anastomosing channels. Some of them are in fact shaped like sweet potatoes or cucumbers, tapering from 30 to 50 μ in diameter at the widest part to 10 to 20 μ at the point where they join another sinus or vein. Very narrow anatomoses or connecting tubules (''Verbindungsröhrchen'') of Weidenreich ('01) are shown in figure 3 (lower right, SC) and in figure 10 (lower center). Broader anastomoses are illustrated in figures 2, 4, 5 and 10. Sinus length is quite variable. Measurements from 90 to 700 μ were recorded.

The longest and widest sinuses were found encircling the lymphatic nodules, with a marginal zone of delicate reticulum separating them from the coarse fibers of the nodule proper. These perinodular sinuses are shown in figures 4, 5, and 9. When viewed as from the nodule, they appear as broad and somewhat flattened structures with frequent broad anastomoses with neighboring perinodular sinuses as well as with the smaller interstitial sinuses. These large sinuses have the most direct drainage routes into the venous tributaries. In some cases the terminal venous branch arches directly into a perinodular plexus. Such an arrangement of sinuses would seem to facilitate the removal of the products formed by the nodules, viz. lymphocytes and possibly blood plasma. MacNeal ('29) and Koboth ('39) both indicate that the nodular capillaries, especially the marginal ones, are permeable to plasma. According to MacNeal ('29), in the human and rabbit, the largest sinuses are farthest from the nodules and go to form the boundary of his splenic lobule.

As to structure, the sinus wall does not differ markedly from the descriptions of Weidenreich ('01), Mollier ('10), Foot ('26), Jäger ('28), Klemperer ('38) and Koboth ('39). Sections stained by Haidenhain's iron hematoxylin show the characteristic rod-shaped endothelial cells. The annular or ringfibers lying outside the endothelium are very well developed in the guinea pig. In tangential cuts of the longer sinuses they appear as closely-set rungs on a ladder. See figures 5 (lower portion), 19 (right), 21 and 28. In areas where the sinuses are short and anastomoses frequent these fibers form a honey-comb-like mesh (fig. 11).

In the human spleen, Koboth ('39) included as part of the sinus wall a mantel of reticular fibers and cells ("Maschengangmantel"). She described it as made up of the ring fibers ("Ringfaser") and coarse border fibers ("Grenzfaser") running in the center of the pulp cords. Between these two nets run fine vertical or connecting fibers. The border fibers which are so prominent in the human spleen are almost lacking in the guinea-pig. However, in some places a mantle-like fiber arrangement does occur (fig. 21, SM). The signifiance of such an arrangement is discussed below.

Veins. The collecting veins are similar in structure to the larger sinuses. They differ from sinuses in several features: larger diameter, straighter course, gradual acquisition of a trabecular covering and the lack of constricted areas. The contrasts between sinuses and veins are well-shown in figure 12 in which sinuses are marked S and the veins V. The openings of sinus systems into the veins are marked by arrows. In the model (fig. 3), the sinuses of the lower left portion are seen draining into a collecting vein. The same vein is also shown in figure 8.

MacKenzie et al. ('41) stated (p. 413) that, "Each venous sinus by at least one of its extremities, communicates with a vein. We have seen no sinuses which were connected at both ends with other sinuses." From the evidence given above, neither of these statements applies to the conditions found in the guinea-pig. The statements may apply to the cat (and possibly the mouse) if the minute tubes which Robinson ('30) described as the beginnings of the venous system are considered to be sinuses.

The arterial system. The branches of the splenic artery at the hilus penetrate the capsule and immediately are covered by lymphoid tissue (the lymphatic sheath or white pulp). The arteries and their sheaths radiate from the hilus, branching and rebranching. Lymphatic nodules (follicular swellings or Malpighian corpuscles) with germinal centers appear frequently along the continuous lymphatic sheath (fig. 13, LN). The continuous nature of the guinea-pig white pulp and the nature of its reticulum have been briefly described by Downey and Weidenreich ('12). Their statements are in accord with the present findings.

The reticulum of the lymphatic sheath is very characteristic and easily identified. See figures 2, 4, 5, 14, 15, 16 and 17. With the exception of the germinal centers, it consists of a network of coarse fibers between which is a web of fine fibers (figs. 15 and 16). This type of reticulum also continues around the outer zone of the nodules (fig. 4). The fibers of the germinal centers are notoriously difficult to impregnate. The nodular fibers in figure 17 show somewhat better than is usually the case.

The arterial supply to the nodules and the penicilliar system of the guinea-pig is similar to that described by Jäger ('28) for the human, with the exception that no reticular sheathes of Schweigger-Seidel are demonstrable in the guinea-pig. An artery supplying the inner vascular net of a nodule is shown in figure 17. The beginnings of penicilli are shown in figure 2 (emerging from left of lymphatic sheath), figure 4 (lower right corner) and figure 6 (shown emerging at various points form the white pulp portion of the model).

The first branches of the penicilli contain many reticular fibers in the media and are therefore easy to trace in silver impregnated sections. The finer terminal branches, the arterial capillaries, consist of endothelium surrounded by a delicate net of fine wavy reticular fibers, the "adventitia capillaris" of Maresch ('05) (reference from Klemperer, '38). The small vessels, 6–9 μ in diameter, can be traced for several hundred micra through the pulp cords, their reticular covering standing out sharply in contrast to the reticulum of the pulp cord. See figures 19, 21, and 28 (AC).

The exact manner of the final termination of the arterial capillaries is still a subject of debate. Figures 18 through 29 are photomicrographs illustrating three types of terminations which are to be found in the guinea-pig. Some terminate as ampullary dilatations as shown in figures 18, 19 and 20. MacKenzie and others ('41) saw them in the living spleen and described them as follows, "— the guinea-pig's ampullae are blunt, club-shaped structures, bent backward somewhat upon the shaft of the vessel — ", a description which amply describes those pictured. The ampulla is covered by a fine reticulum similar to that of the arterial capillary. The ampullae shown in figures 18 and 19 are 18 μ and 13 μ, respectively, in their widest diameters. Some ampullae open widely into an adjacent sinus (figs. 3 and 5, A.M.). From other ampullae (fig. 18 and 19) arise several small efferent vessels which may run for some distance in the pulp cords before terminating in one of the ways described below. The term arterial sinus could be used for such an arterial dilatation. The efferent connections, if any, of other ampullae are often obscure because of unfavorable planes of section.

Many examples of direct arteriolar-sinus connections have been observed in the guinea-pig series. Several examples are shown in figures 21–25. In figure 21, the arterial capillary is shown entering the sinus wall obliquely at a point where two sinuses merge. The fine reticular fibers of the arterial capillary merge with the coarse annular fibers of the sinus. As the artery passes toward its opening into the sinus lumen, the diameter increases from 6 to 12 μ. Careful focusing shows that the vessel is patent. In figure 22 the artery is seen opening into the connecting tubule between larger sinuses. In figure 23 two adjacent sinuses each have direct arteriolar connections at their upper ends.

Another type of arterial connection is shown in figures 26–29. The arterial capillary can be traced to a point close to the sinus whereupon the reticulum sprays out to blend with the sinus fibers, forming a funnel-shaped fenestrated maze with no clear cut channel in evidence as have those in the preceding group. The fenestrated segment may be long as in figure 28 or short as in figure 27. The meshes of the connecting segment in figure 27 are filled with hemosiderine granules. This type of connection is somewhat like Klemperer's ('38) diagram (upper portion) of the intermediate circulation of the human spleen.

There are also some areas in the guinea-pig spleen which resemble Koboth's ('39) mantle type of arterial-sinus connection. According to this concept, blood is supplied by the arterial capillaries to a "Reticuloendotheliale Kapillarplexus" which is situated between the annular and border fibers of the sinus mantle. The blood moves into the sinus from this plexus by way of pores in the sinus walls.

> "Nachdem das Blut in den arteriellen Lymphscheiden bereits Plasma verloren hat, wird es, eingedickt, von den verzweigten arteriellen Endkapillaren in die, jeden Venensinus mantelförmig bekleidenden reticulokapillären Plexus abgegeben: dort, in diesen Plexus eine breite Hülle bildend, der Venensinuswand entlang und durch ihre Lücken in den Venensinus hineingeschoben. Von dem Venensinus plexus fliesst das Blut schliesslich in die Pulpavenen ab."

The Koboth concept differs from that of Klemperer in that it brings the arterial capillary into much more intimate relationship with the porous sinus walls. In the guinea-pig, arterial capillaries have been traced into distended reticular meshes embracing portions of sinuses.

These areas are often somewhat crescent shaped. In the preparations available there is no good evidence that large amounts of blood are poured into the pulp cords from open arterial capillaries or from porous ampullae as MacNeal ('29) has described for the human and rabbit. A few red cells can usually be found in the pulp cords but nothing like the flooding which occurs in the mouse. That connections in the guinea-pig differ from the other animals they studied is indicated in MacKenzie's and others statement that, ''In the guinea-pig spleen, rhythmical contractions have a less marked effect — '' on the presence of extra vascular red cells, paling of the pulp and cessation of flow in the arterial capillaries.

COMMENTS

In view of the above evidence, the guinea-pig should not be included in the following quotation from MacKenzie's and others summary, ''In the spleens of mice, rats, rabbit, guinea-pig and cats, there are no preformed, intactly wall connections between the arterial and venous systems,'' Also, it would seem that the mechanism of red cell storage in the guinea-pig with its extensive sinus systems and relatively insignificant pulp spaces cannot be ''fundamentally the same'' as in the mouse where ''swamp-like pulp zones'' are so predominant.

It is likewise difficult to understand how Knisley could approximate certain features of the guinea-pig spleen (arterial sinus connections and general sinus pattern) through his studies of the spleens of the mouse and cat. If, as MacKenzie et al. claim, ''the transilluminated appearance of the venous sinuses is fundamentally the same in all species we have examined,'' an attempt at an explanation would be pure conjecture. The interruption or diversion of the circulating blood by ''mobilized'' reticulo-endothelial cells within sinuses, especially near arteriolar terminations, might simulate the appearance of blood within reticular pulp spaces. Stellate cells are sometimes seen in the sinuses of fixed spleens, and large mononuclear phagocytes containing hemosiderine are very numerous. Experiments are under way to determine whether the process of exteriorization, exposure to bright light, or temperature changes produce any marked effect on the reticular cell pattern or red cell distribution.

SUMMARY AND CONCLUSIONS

1. A wax plate reconstruction showing a portion of the venous sinus network of the guinea-pig spleen has been made.

2. The sinus system consists of a series of completely patent anastomotic channels which are drained at various points by collecing veins.

3. An especially large set of sinuses "embraces" each lymphatic nodule.

4. Arterial capillaries have been observed to open directly into sinuses. Other connections by way of fenestrated arteriolar terminations are also illustrated.

5. Contrasts between the intermediate circulation in spleens of the guinea-pig type and the cat and mouse type are discussed. Similarities between the human and guinea-pig spleens are stressed.

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ABBREVIATIONS

A, artery
AC, arterial capillary
AM, arterial ampulla
C, capsule
L, lymphatic sheath
LN, lymphatic nodule of white pulp
MZ, marginal zone
P, pulp cord
R, reticulum
S, venous sinus
SC, intersinus connecting tubule
SM, sinus mantle
T, trabecula
V, vein

PLATE 1

EXPLANATION OF FIGURES

1 Photograph of the model with three plates in place. × 67.

2 The silver-impregnated section of guinea-pig spleen from which the upper plate of figure 1 was made. × 67.

3 The completed model with white pulp in place. × 67.

4 Section taken through the widest part of the germinal center of the model series. × 67.

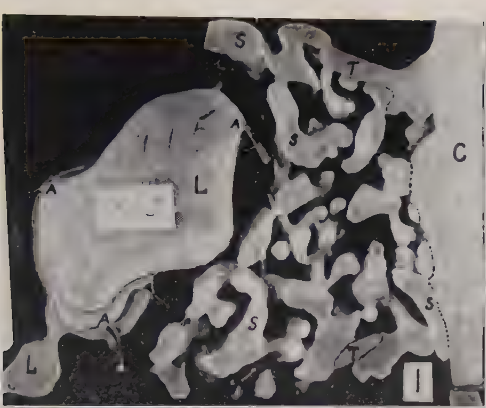
5 The section from which the final plate of the model was made (fig. 3) × 67.

6 The white pulp after removal from the model. × 67.

7 Side view of the completed model looking down from the top of figure 3. White pulp in place. × 67.

8 Side view of the completed model looking up from the bottom of figure 3. White pulp in place. × 75.

9 Side view of the model looking into the recess formerly occupied by the white pulp. × 90.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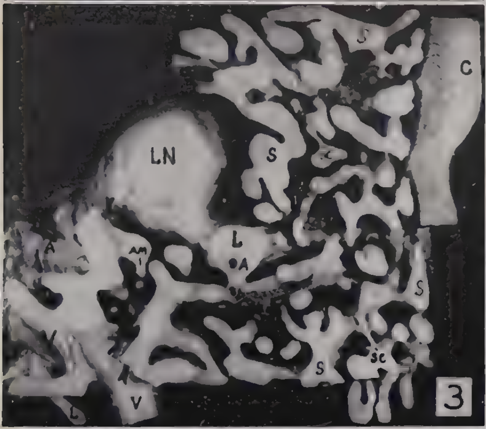
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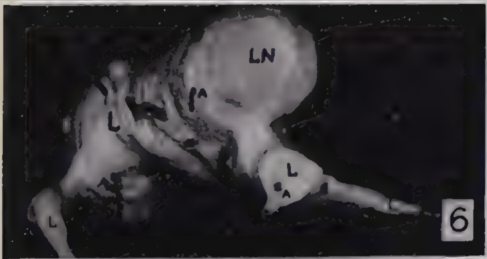
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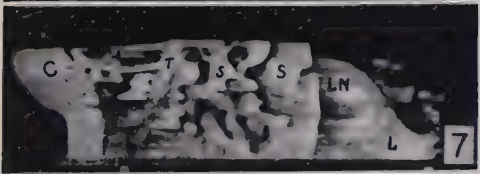
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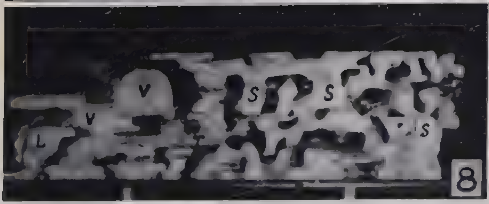
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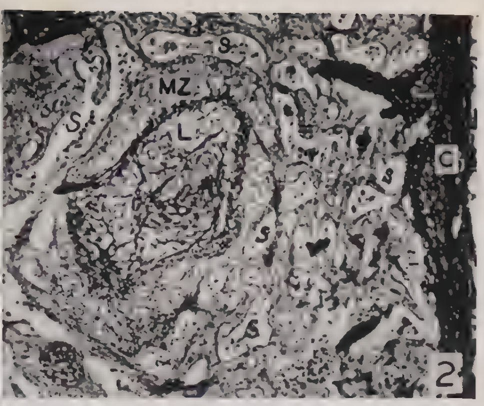
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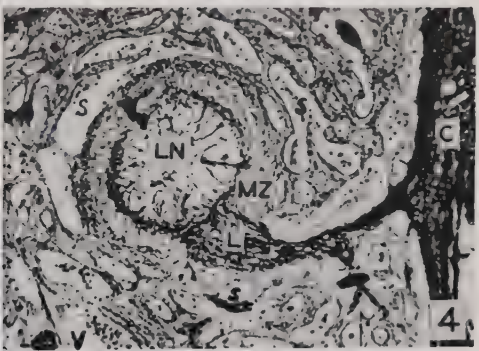
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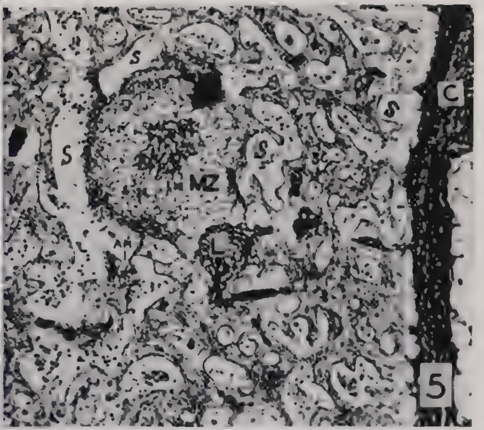
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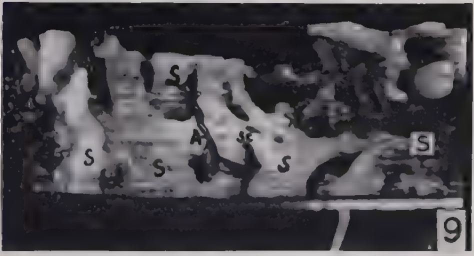
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PLATE 2

EXPLANATION OF FIGURES

10 Small portion of red pulp of guinea-pig spleen showing several sinuses, arterial branches and pulp cords. Silver impregnation. × 216.

11 The same, showing the reticular fibers of the sinus walls. × 216.

12 Collecting veins with sinus openings indicated by arrows. Silver impregnation. × 85.

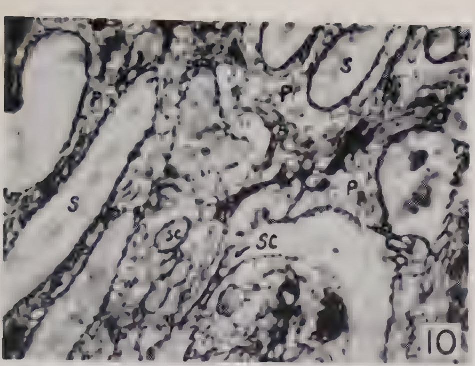
13 Hilus region of guinea-pig spleen showing an arterial branch and its lymphatic sheath running up through the center of the photomicrograph and branching near the top. Two nodules are indicated (LN). × 35.

14 Frozen section of guinea-pig spleen showing the reticulum of the lymphatic sheath (white pulp). Silver impregnation. × 45.

15 Higher power view of the artery shown in figure 14. × 206.

16 White pulp reticulum from the top of figure 14. × 120.

17 Frozen section of guinea-pig spleen showing the reticulum of a lymphatic nodule. × 146.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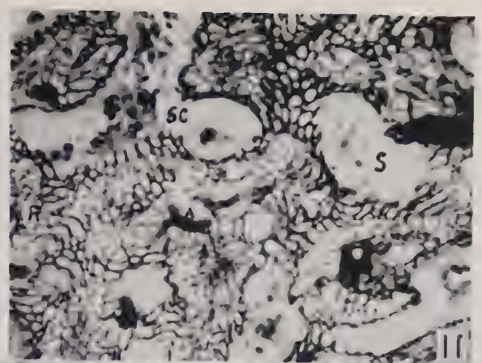

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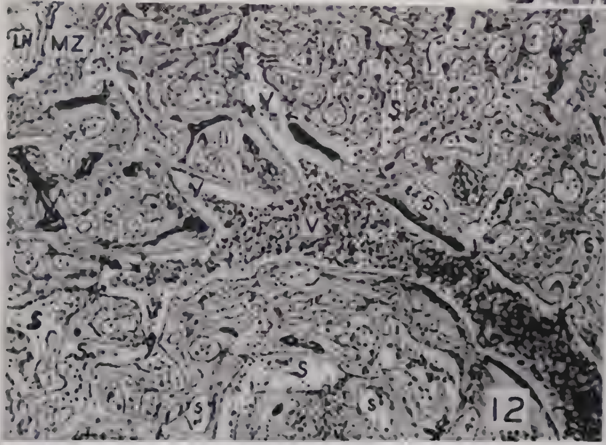
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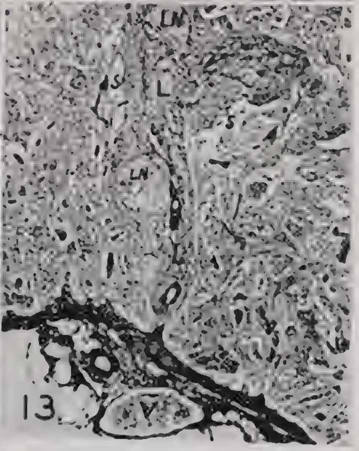

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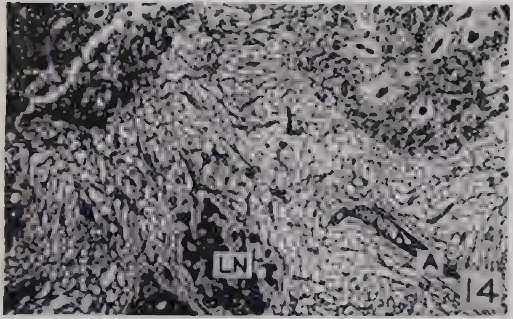

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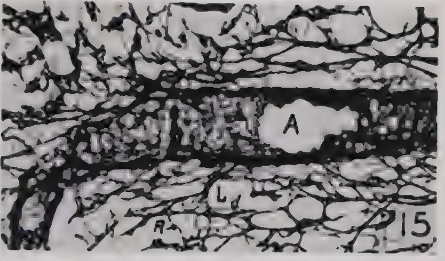

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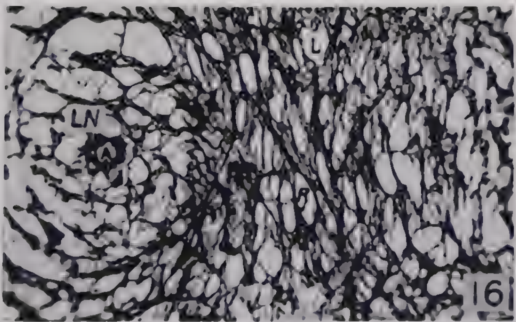

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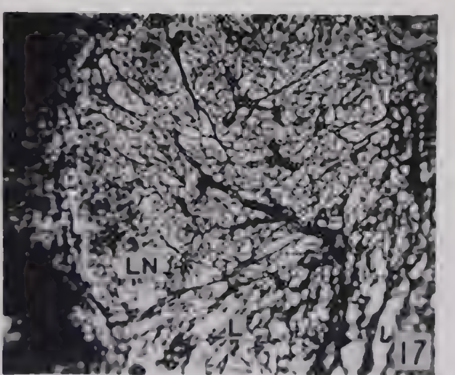

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PLATE 3

EXPLANATION OF FIGURES

18 Red pulp showing sinuses and an arterial capillary with an ampullar dilatation. × 434.

19 An arterial capillary ending in an ampulla. × 365.

20 A branched arterial capillary with an ampulla. × 365.

21 An arterial capillary opening into a sinus. Arrows indicate the course of the vessel. × 365.

22 An arterial capillary opening into an intersinus connecting tubule. × 365.

23 Two arterial capillaries opening side by side into adjacent sinuses. × 365.

24 An arterial capillary opening into the end of a sinus. × 434.

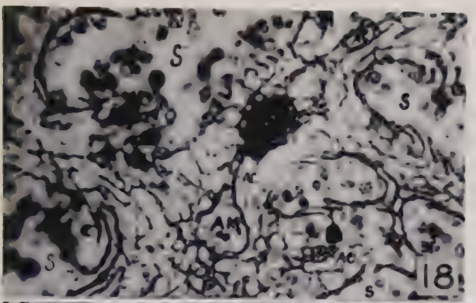
25 A branchial arterial capillary with the lower branch entering a sinus. × 465.

26 An arterial capillary ending in a reticular maze at the end of a sinus. × 465.

27 An arterial capillary ending at the side of a sinus. Hemosiderine is present in the meshes. × 600.

28 An arterial capillary ending as a funnel-shaped maze of reticulum which blends with that of the sinus wall. × 434.

29 An arterial capillary ending in a net of reticulum just outside a sinus wall. × 600.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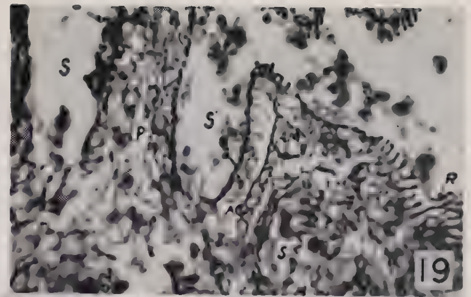
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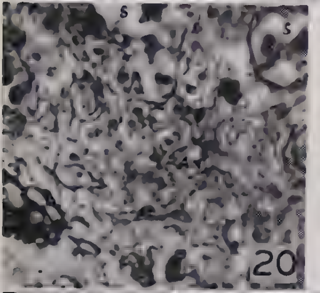
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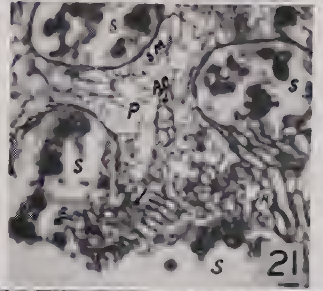
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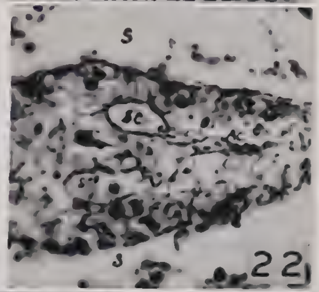
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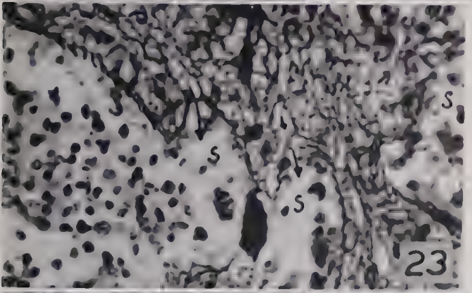
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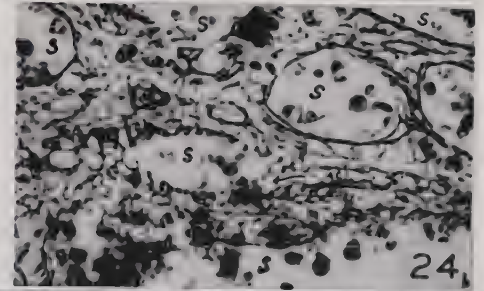
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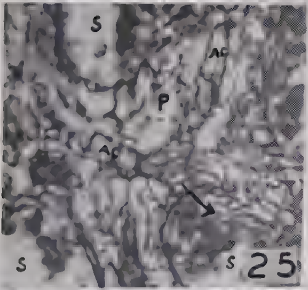
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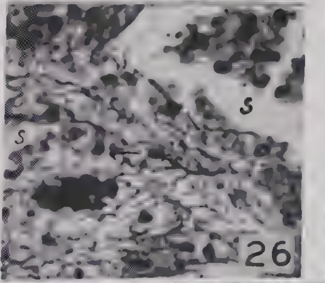
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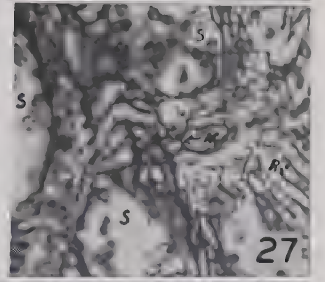
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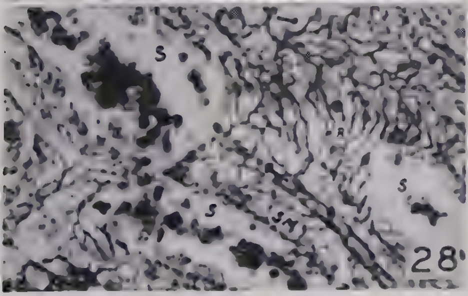
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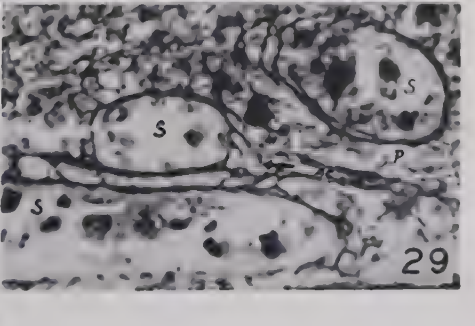
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THE ANATOMY OF THE TONGUE OF THE DOMESTIC NORWAY RAT

I. THE SKIN OF THE TONGUE; THE VARIOUS PAPILLAE; THEIR NUMBER AND DISTRIBUTION

H. S. FISH, P. D. MALONE AND C. P. RICHTER
Psychobiological and Anatomical Laboratories, Johns Hopkins Medical School, Baltimore, Maryland

SIX FIGURES

Three recent developments in the field of nutrition have given a renewed impetus to the study of the anatomy and physiology of the tongue; (1) clinical and laboratory investigations have shown that the tongue undergoes marked changes during various dietary disturbances and deficiencies (Jeghers, '42); (2) experimental studies have shown that under a wide variety of glandular and nutritional disturbances animals are able to make beneficial dietary selections from natural as well as purified foodstuffs: fats, carbohydrates, proteins, minerals and vitamins. The results of these studies indicate that appetite of animals may be used as a guide to dietary deficiencies. The importance of the tongue in making these selections is attested by the finding that section of the taste nerves greatly reduces or completely abolishes this ability (Richter, '42–'43); (3) the observations of Fox ('32), Blakeslee ('32), Snyder ('32) and others have shown that 5 to 10% of all individuals are entirely unable to taste phenylthiourea and other closely related bitter tasting substances and that this inability is inherited as a Mendelian recessive. Here again we have little or no knowledge regarding the anatomical basis of these taste defects. Nothing is known regarding the inheritance of morphological differences in the tongue.

In an effort to throw some light on these different phenomena we have undertaken a series of studies on the anatomy and physiology of the tongues of animals and human beings. The present report deals largely with the superficial anatomical characteristics of the rat's tongue, the epithelial covering, and the number, shape and distribution of the papillae. Later studies will deal with nervous innervation and dietary selection experiments. The rat's tongue was chosen for this first study since most of our knowledge of normal nutrition and of the reliability of appetite as a guide to dietary needs comes from observations made on this animal.

METHODS

A solution of 0.1% methylene blue in 5% formalin injected through the right and left carotid arteries (10 to 15 cc. in each) just above the heart, stained the fungiform and foliate papillae a vivid blue and thus made it possible to record their number and distribution. Special care was taken in removing the tongue to prevent any of the stain from coming in contact with its surface. After washing briefly in running water, the tongue was impaled on the end of a dissecting needle which was supported in an upright wooden stand in such a way that it could be rotated and depressed or elevated. The papillae were observed under a dissecting microscope with a suitable magnification. Each fungiform papilla was reproduced as a dot on a large scale chart of the tongue. A record was then established not only of the total number of these papillae on the surface of the tongue but also of the numerical differences of the two sides. The result of such a count in 103 rats ranging in age from 8 hours to 466 days is reported here.

Special knowledge of the dermal characteristics of the various papillae was obtained by immersing freshly removed tongues in Sihler's macerating fluid for 24 to 48 hours according to the procedure used by Wharton ('37). With this treatment the epithelium became wrinkled and separated from the underlying dermis and could then be removed in a single piece. Common histological techniques supplemented the study of the cell organization of various parts of the tongue.

The rats used for these observations were descendants of albino stock from The Wistar Institute and hooded stock from the colony of Dr. E. V. McCollum. No new stock has been added during the past 16 years. Some were albino, others black or tan hooded, others all tan.

GROSS CHARACTERISTICS OF THE RAT'S TONGUE

The rat's tongue (fig. 1A) is a long, slender and quite flexible organ. As in most rodents, the posterior surface is somewhat elevated into a broad, flatly curved prominence the forward end of which comes to a blunt and sloping point just short of the middle of the tongue (fig. 1C). The anterior surface of the tongue is divided longitudinally by a shallow groove which terminates in a notch at the tongue's tip. These features become exaggerated after fixation in formalin.

The epithelium completely covers both fungiform and filiform papillae and is sufficiently thick between them to give a generally even surface to the tongue. Only the cornified spines of the filiform papillae rise above this general surface. After the epithelium has been removed, the dermal cores of the fungiform papillae stand out clearly on the otherwise even surface of the dermis and can be seen with the

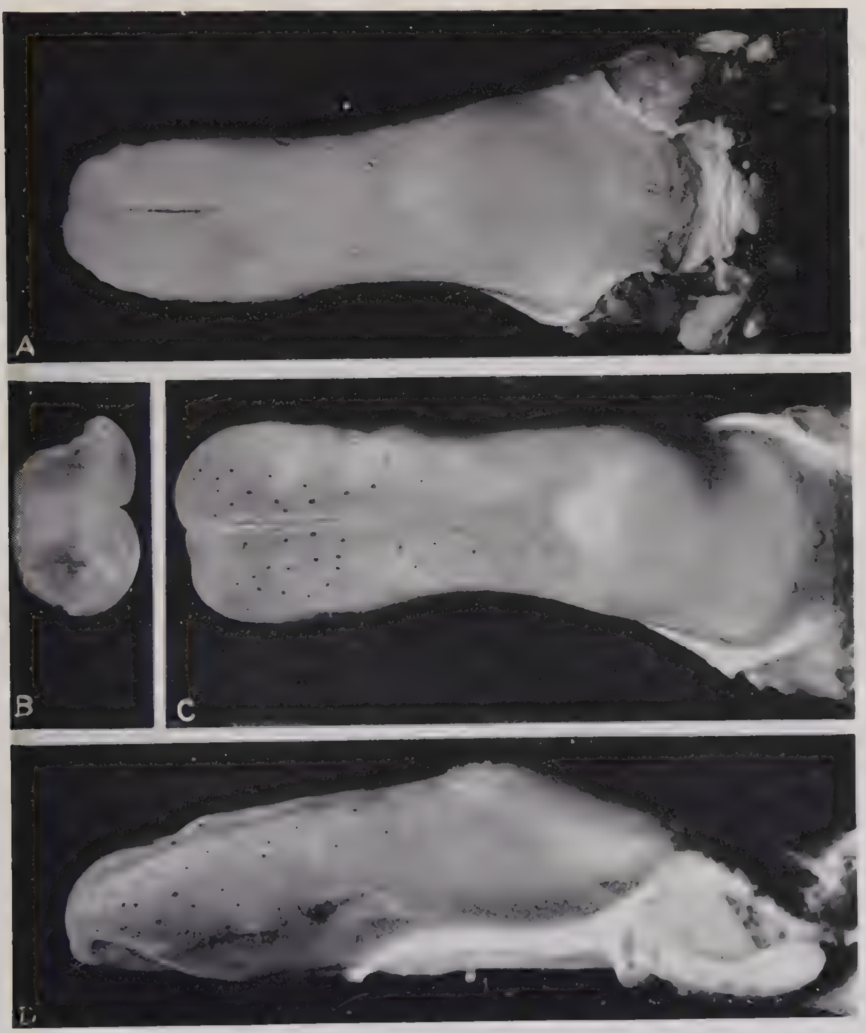

Fig. 1 A Freshly removed rat's tongue.
B Frontal view of tongue's tip after injection with methylene blue.
C Surface view of tongue after injection.
D Lateral view of tongue after injection.

unaided eye (fig. 2A). The epidermal cells which remain in the grooves of the foliate papillae and in the trench of the circumvallate papilla emphasize the outlines of these structures.

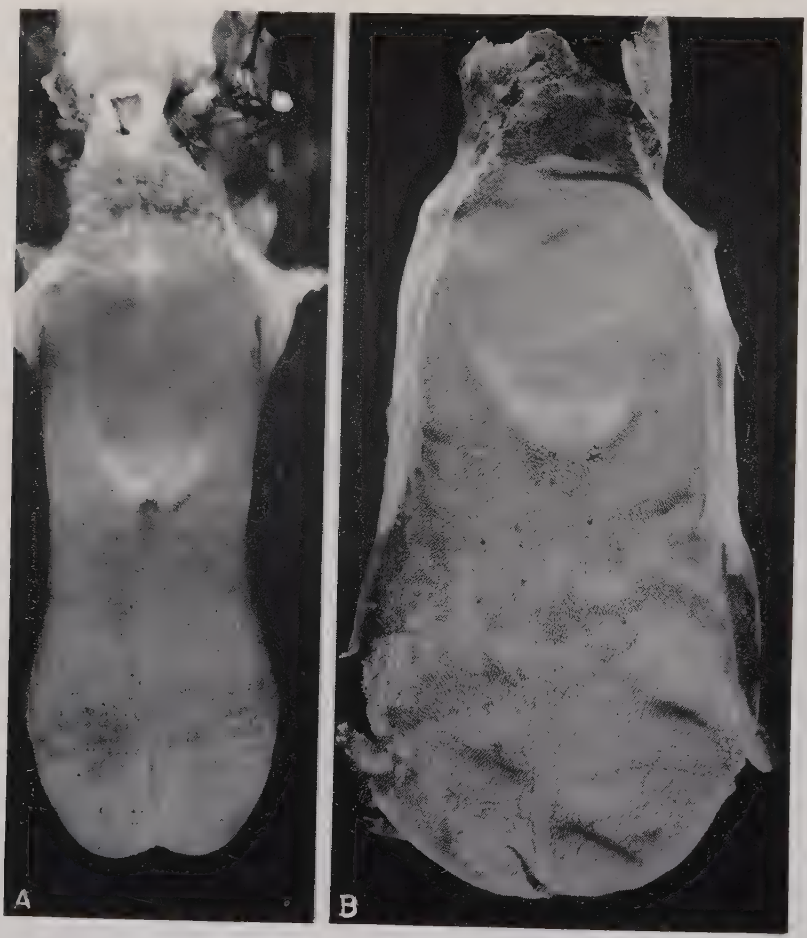

Fig. 2 A Surface of tongue after removal of the superficial skin or epithelium.
B Skin removed in one piece.

FUNGIFORM PAPILLAE

Fungiform papillae (fig. 3B, 3C) are largely dermal in structure, consisting of connective tissue elements, a unique capillary network and nerve fibers. The epithelium covering the dermal core is reduced to a few layers of thin cells except for the single taste bud which rests in a depression on top of the papilla core. A short and narrow channel above the taste bud opens onto the surface of the tongue through a pore which is rarely visible from a surface view of the tongue even with higher power magnification. The relative thinness of the epithelium above these papillae doubtless accounts for their deep blue color when the tongue is injected with methylene blue.

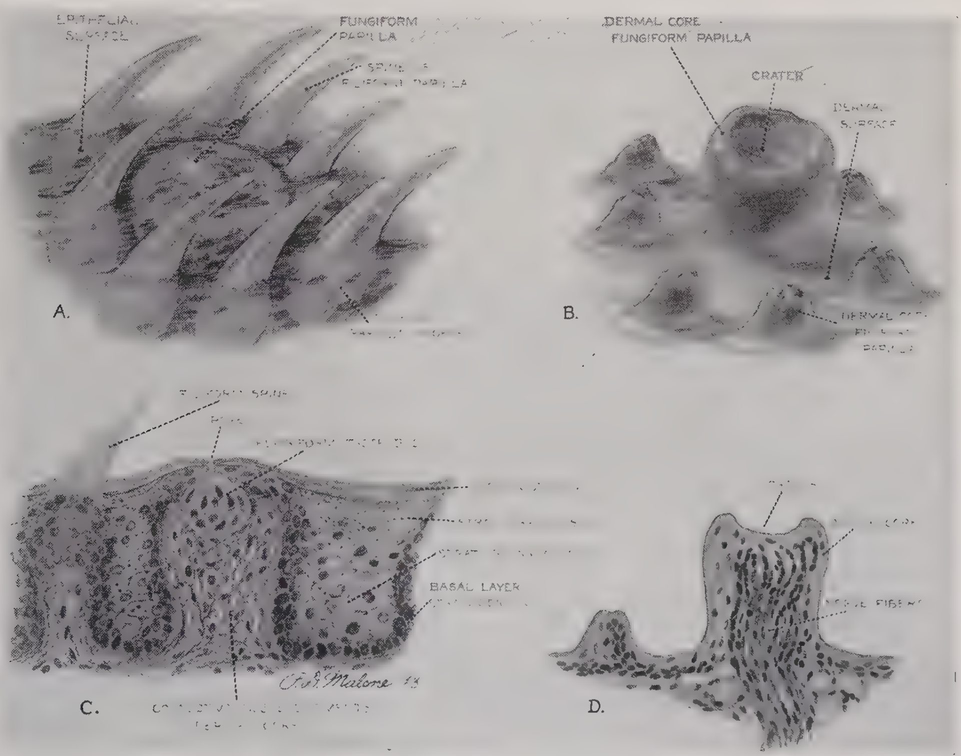
EPITHELIAL SURFACE
FUNGIFORM PAPILLA
DERMAL CORE FUNGIFORM PAPILLA
CRATER
DERMAL SURFACE
A.
B.
BASAL LAYER
NERVE FIBERS
C.
D.

Fig. 3 A Drawing of tongue's surface showing filiform and fungiform papillae.
B Dermis after removal of the epithelium.
C Vertical section of the filiform and fungiform papillae.
D Vertical section of the filiform and fungiform papillae after removal of the epithelium.

The total number of fungiform papillae varied from 114 to 221 papillae per tongue, the average being 178.8. Figure 4A gives a frequency-distribution curve for these papillae. The average number of papillae remained essentially the same at all ages from 8 hours up to 466 days.

FILIFORM PAPILLAE

The filiform papillae are distributed over the entire free surface of the tongue except for the region between the circumvallate papilla and epiglottis, beneath the foliate papillae, and on the under side of the tongue from the frenulum nearly to the tip. The papillae are represented externally by numerous slender, cuticular spines which curve backward above the surface of the tongue. The largest spines are located in a broad patch on the forward sloping portion of the dorsal prominence and the shortest ones occupy the sides and under part of the tip of the tongue. Elsewhere on the tongue's surface they maintain an intermediate and constant size.

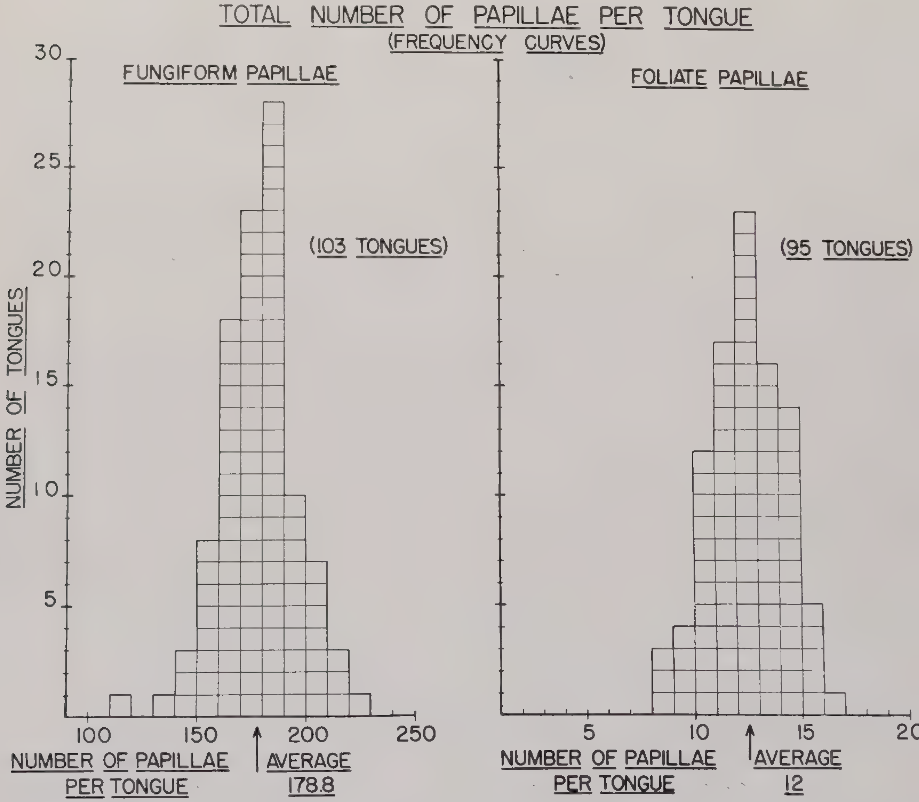

Fig. 4 A Frequency distribution chart showing number of individual tongues and total number of fungiform papillae per tongue.
B Same for the foliate papillae.

The structure of the filiform papillae as represented in figure 3C is drawn somewhat off center. Most of their epithelial portions lie entirely beneath the level of the tongue's outer surface but a small cone-shaped tip enters the base of the spine. The epithelium is several times thicker than that covering the dermal core of the fungiform papillae and consists of many layers of squamous cells. The superficial layer shows a rapid transition into the cuticular material of the projecting spines.

When the epithelium is removed there remain small, conical mounds representing the dermal cores of the filiforms (fig. 3B). Compared with the dermal cores of the fungiform papillae these are much shorter and more slender. They are fairly uniform in height and their free ends are often pointed but never concave.

FOLIATE PAPILLAE

The foliate papillae are located on the dorso-lateral border of the tongue just anterior to its attachment to the sides of the oral cavity. In this region the surface epithelium sinks into the underlying dermal structure to produce a series of parallel grooves or furrows generally uniform in length and spacing. They lie approximately in the transverse axis of the tongue. Figure 5A presents a typical surface view of the foliate papillae. In a number of rats the grooves were longer or shorter than the average, or had the form of a "V", a "Y", or an "H". Figure 5C is a drawing of a vertical section through the foliate area. The epithelium is thickened between furrows but becomes markedly thinner on their vertical sides and tends to thicken again in the floor. The

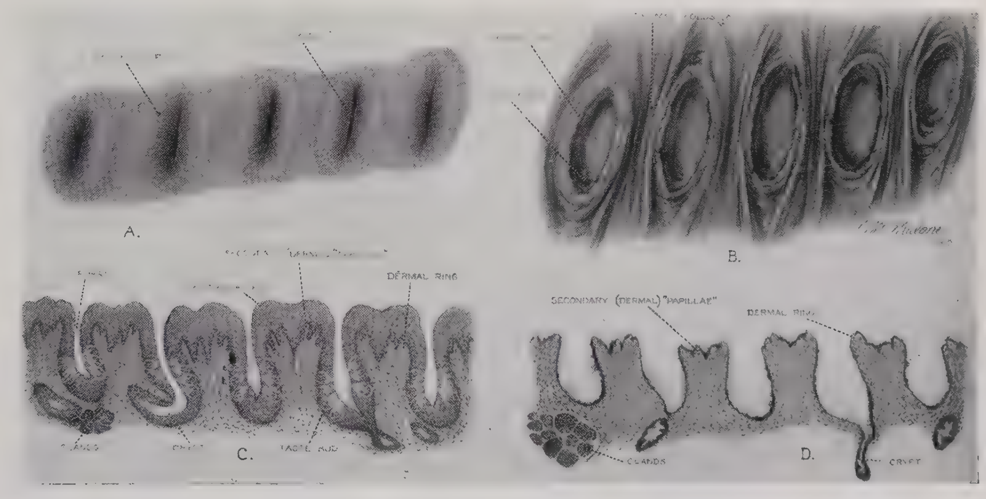

Fig. 5 A Drawing showing surface view of foliate papillae on one side of the tongue.
B Surface view of foliate papillae on one side of the tongue after removal of the epithelium.
C Vertical section of the foliate papillae.
D Vertical section of the foliate papillae after removal of the epithelium.

many taste buds, more or less limited to the lower half of these walls, occupy the entire thickness of the epithelium.

At either end of the floor of each groove small pocket-like crypts extend for some distance into the tissue of the tongue and nearly parallel to its surface. Ducts from serous glands deeply imbedded in the muscle of the tongue open into the floor of the furrows, particularly into the crypts.

Removal of the epithelial layer by treatment with Sihler's solution leaves the papillae as a series of large gaping openings on the sides of the tongue (fig. 5B), and between them the exposed dermis is raised into a number of elongated and nearly parallel ridges. It is these ridges which appear as secondary dermal papillae in vertical sections through the foliate area (fig. 5C and 5D).

The foliate papillae of the rat undergo most of their development postnatally. After the second day they can be counted accurately. Eight tongues from 1-day-old rats in which the foliate papillae could not be counted are not included.

The total number of foliate papillae on both sides of the tongue range from 8 to 15, the average number being 12. Figure 4B gives the frequency distribution of these papillae and shows that the maximum frequency falls at 12 per tongue. The papillae were equally divided on the sides of 36 tongues. Twenty-six tongues had from 1 to 5 more papillae on the right side. Thirty-three tongues had from 1 to 3 more on the left side.

THE CIRCUMVALLATE PAPILLA

Anatomically, the circumvallate papilla of the rat differs markedly from that of other mammals as shown in figure 6A. First, it occurs as a single papilla in the midline of the tongue near its base. Second, the central part of the papilla proper is elongated in the central axis of the tongue. Its anterior end is considerably broader and higher than its posterior end. Third, the papilla proper is separated from the surrounding structures by a trench on three sides only, lateral and posterior. Fourth, the semi-circular trench opens broadly on the surface of the tongue, and presents a sac-like appearance.

The morphology of the circumvallate papilla as seen under the microscope bears out these unique characteristics. A transverse section across the anterior end of the papilla (fig. 6C) resembles that of a typical circumvallate papilla. The expanded top of the mushroom-like central portion is separated from the outer walls by the forward ends of the lateral arms of the trench. Its surface is somewhat higher than the general surface of the tongue. But, in a sequence of more posterior sections, the central papilla becomes shorter, more slender and triangular in outline. Simultaneously, the outer walls of the trench converge and eventually fuse above the extreme back part of the central papilla. Sections of the region just behind the end of the papilla show a transversely oval cavity below the surface of the tongue which represents

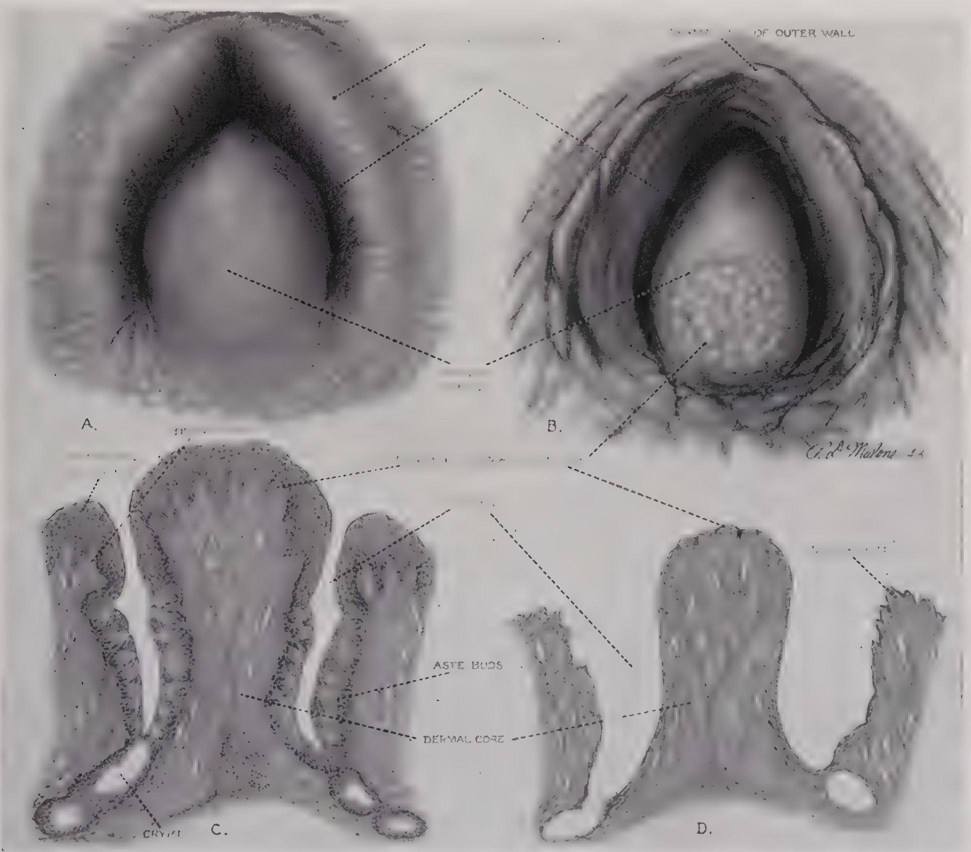

Fig. 6 A Surface view of a circumvallate papilla.
B Surface view of a circumvallate papilla after removal of the epithelium.
C Vertical section of circumvallate papilla.
D Vertical section of circumvallate papilla after removal of the epithelium.

the most posterior extension of the sac. Numbers of finger-like crypts extend from the floor of the trench into the surrounding connective tissue, and into them open the ducts of serous glands as in the case of the foliate papillae.

The histological characteristics of the circumvallate papilla in the rat are similar to those of other mammals. The epithelium of the tongue covers the papilla and lines the trench and crypts. In sections of the region (fig. 6C), the epithelium is particularly thickened over the outer rim of the trench and here its inner surface is strongly serrated by secondary dermal papillae. The dermal papillae are small and regular under the epithelium of the highest portion of the central papilla (fig. 6C, 6D).

The taste buds of the epithelium are situated on both sides of the deeper portion of the trench. They are characteristically like the taste buds of the foliate papillae, but are relatively more numerous.

Following treatment with Sihler's solution, the epithelium of the deeper portion of the circumvallate papilla may be removed with some difficulty. A surface view of such a papilla (fig. 6B) exaggerates the sac-like character of its surrounding trench. The dermis bordering the outer rim of the trench bears a semicircular crown of short folds whose ends overlap. This accounts for the striking appearance of the dermal papillae as seen in cross sections of this region. Removal of the epithelium from the anterior end of the central papilla reveals a disc-shaped area of dermis with a pebbly surface. A shallow transverse groove unites the forward ends of the lateral arms of the trench across the front of the papilla.

DISCUSSION

The present report covers some of the more general aspects of the structure of the rat's tongue and includes the organization of the epithelium, its relation to the dermis and characteristics of the various papillae. Particular attention is given to the latter in as much as the rat's tongue appears to be devoted chiefly to the function of taste. Details concerning the nerve supply to the taste buds have been purposely omitted here as they will be treated in a separate paper.

The epithelium presents several features which may prove to be unique for the rat. (1) The epithelium is not uniformly thick over the tongue's surface. The contrast is especially marked between the few layers of cells capping the fungiform papillae and the many layers which immediately surround them. (2) This leads directly to the observation that the external surface of the epithelium is essentially level since the fungiform papillae do not rise appreciably above the surface of the tongue. The conical spines of the filiform papillae are a conspicuous feature of the tongue's surface, but they are cuticular having lost their cellular characteristics. (3) The dermis plays a more conspicuous part in the organization of fungiform papillae of the rat than is found for other animals. This is shown in histological sections and especially by the use of Sihler's macerating fluid. After the epithelium has been removed by this agent, the fungiform papillae appear as dermal pillars with a depressed top (where the taste bud was located) and they stand out with extraordinary sharpness among the countless but relatively minor dermal cores of the filiform papillae. This is a striking reversal of their relative anatomical appearance in the intact tongue.

The nearly parallel folds of dermis under the epithelium between the foliate papillae have not been described before. It is likely that the application of Sihler's fluid to a wide variety of tongues will show them to have a similar dermal arrangement between these furrows.

The circumvallate papilla of the rat seems unique on two counts, its morphology and its singleness. Of all the varieties of mammalian tongues examined in this laboratory only the rat is possessed of a single one. Furthermore, in only the rat is the central papilla of the circumvallate type elongated markedly in the axis of the tongue and surrounded by a semicircular trench. It appears that this form of the papilla and the forward direction of the opening of the trench are adaptations on the part of this animal to facilitate the functional capacity of the circumvallate papilla in compensation for its numerical reduction.

Previous statistical data in the literature on the taste papillae are limited almost wholly to the circumvallate type. So far as we know, there is no recorded data as to the number of fungiform papillae of the tongue. Through methods used in preparing the reported data an accurate count of the fungiform papillae has been made for the rat's tongue. The wide variations in the different counts suggest the possibility that these papillae may be useful in genetic studies, especially in such easily bred animals as the rat.

SUMMARY

1. The rat's tongue is covered with a typical multi-layered skin which can be removed in a single piece after treating the tongue with Sihler's solution.

2. The fungiform papillae which are distributed over the forward half of the surface of the rat's tongue lie entirely within the thickness of the epidermis. The single taste bud on the top of each papilla is removed with the skin after treatment with Sihler's solution.

3. The average number of fungiform papillae on the tongues of 103 rats was 178.8.

4. The foliate papillae are parallel grooves on either side of the tongue near its base. The average number of grooves in 95 tongues was 12. The taste buds are imbedded in the epithelium of the walls of the grooves and can be removed with the skin.

5. The single circumvallate papilla is located in the midline of the tongue near its base, and is surrounded on three sides by a deep trench. The numerous taste buds in the epithelium of the walls of the trench can also be removed with the skin.

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CORRELATIONS BETWEEN WOUND HEALING AND REGENERATION IN FORE-LIMBS AND TAILS OF LIZARDS [1]

LUCIE WELLES BARBER
Smith College, Northampton, Massachusetts

TWO PLATES (FIFTEEN FIGURES)

INTRODUCTION

Because tails of lizards regenerate and limbs do not, a comparative study has been made of wound healing in the two regions with the hope that the factors preventing limb regeneration might be discovered. A good description of regeneration of the tail in lizards has been given by Woodland ('20) and Sibtain ('39).

Much of the work which furnishes the background for the present study has been carried out upon Amphibia. In the adult frog, as in the lizard, the limb is incapable of regeneration. After amputation the old skin pinches down over the wound (Rose, '42). Skin will prevent the regeneration which occurs normally in the urodeles. Tornier ('06) amputated Triton tails and sewed skin completely over the amputation surface. Godlewski ('28) performed a similar operation with axolotl tails. The results were the same in both cases — no regeneration when the wound was sealed by skin. The idea that the absence of a complete skin over an amputation wound is a prerequisite for regeneration has been strengthened by recent experiments on normally non-regenerating frogs. They may be made to regenerate by preventing rapid wound closure by a complete skin (Rose, '44).

In the light of the above experiments, particular attention has been paid to the skin in relation to the surface of the wound in both the fore-limb and tail of the lizard to ascertain whether its position determines whether or not regeneration may occur. This study has been carried out under the suggestion and encouragement of Dr. S. Meryl Rose to whom I wish to express my gratitude.

MATERIALS AND METHODS

Twenty lizards, Anolis carolinensis, the common American chameleon, were kept in glass containers lined by absorbent paper and covered by cheese cloth where the temperature ranged from 25° to 29°C.

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[1] Contributions from the Department of Zoology, Smith College, no. 206.

An aerating device bubbled air through water in the cages, continually keeping the atmosphere somewhat moist. The animals were fed fresh toad and frog liver, forcibly, three times a week, and were frequently exposed to direct sunlight for short periods of time to prevent vitamin D deficiency. All lizards were healthy and active throughout the experiment.

Healing in fore-limbs and regeneration in tails of animals used for a preliminary study were observed macroscopically after amputation. The tail and right fore-limb of each of ten animals were used for a detailed histological study and were amputated on the same day. The tails were cut between the tenth and eleventh tail segments; the limbs between the wrist and elbow joints. Macroscopic observations were again obtained. After a definite period of healing, the tail and limb of the same lizard were amputated at a higher level than the original cut for histological comparison. The cut pieces were fixed and decalcified in Bouin's fixative, imbedded in paraffin, and sectioned at 10 μ. Mounted sections were stained with Mallory's Triple stain. In this way, slides of the following stages of healing in both the limb and tail of the lizard were obtained:

Case 1 — 6 hours after the original amputation
Case 2 — 9 hours after the original amputation
Case 3 — 15 hours after the original amputation
Case 4 — 1 day after the original amputation
Case 5 — 3 days after the original amputation
Case 6 — 6 days after the original amputation
Case 7 — 8 days after the original amputation
Case 8 — 12 days after the original amputation
Case 9 — 17 days after the original amputation
Case 10—43 days after the original amputation

OBSERVATIONS

Macroscopic observations

In all cases the results of the general preliminary study substantiated the findings obtained from animals used for the histological study. Amputated limbs did not regenerate; old skin closed down over the surface of the wound and bone extended to the distal end and in many cases protruded temporarily. Later, scar tissue formed and growth ceased. Amputated tails did regenerate; old skin stayed in its original position, no scar tissue formed, and blastemas developed which differentiated into normally regenerated tails.

Comparing the rates of healing of the limb and tail for animals later studied histologically, a similar rate was indicated for the initial healing. In both regions the surface of the wound dried between 6 and 24 hours, a scab formed between 1 and 2 days and was well developed by the sixth day after amputation.

In three animals, bones of the limb protruded slightly beyond the surface of the wound by 1 day. The amount the bones protruded increased with time up to 7 days of healing after which they were gradually covered by skin and scar tissue. Scabs on the limbs of the other animals made protrusion of bone impossible to see macroscopically. In all cases as healing progressed the skin appeared to close down over the wound. Scar tissue was visible after 17 days of healing when the scab fell off. On the other hand, the skin of the tail never closed down over the wound to an appreciable extent. When the scab dropped off the tail between the eleventh and fifteenth days, a blastema was observed which grew to about 5 mm. in length within 43 days after amputation.

Microscopic observations

During the first day the healing in the limb and tail is very similar histologically. The material exposed at the surface of the wound is partially degenerated by 6 hours, a scab is forming by 9 hours, and epithelium is beginning to spread over the wound by 15 hours after amputation in both regions. Mesenchymal cells resulting from the dedifferentiation are present in both the limb and tail within 24 hours. These similarities are shown in figure 1 (of the limb) and figure 2 (of the tail) 1 day after amputation. The black mass, at the top of the photographs is degenerated material and scab. The limit of the old skin is indicated by the extent of the scales.

The first difference between the healing of the limb and tail is visible in slides of case 3 (15 hours) and case 4 (1 day after amputation). One of the bones in the limb protrudes slightly beyond the surface of the wound, whereas the bone of the tail does not. The old skin in the limb pinches down over the wound slightly. The differences after 1 day of healing becomes increasingly distinct and will be described in more detail.

Case 5, fixed 3 days after amputation. In both the limb and tail a scab has formed, the amount of mesenchymal cells has increased slightly, and the epithelium has developed further. However, in the limb a shrinkage of the distal tissues from the bones is observable as indicated by the protrusion of bone. The tissues of the tail, on the other hand, have remained in their original position following amputation and bone does not protrude. (See fig. 3 of the 3-day tail and notice similarity of the position of tissues as compared to fig. 2 of the 1-day tail.)

Case 6, fixed 6 days after amputation. In the limb shrinkage of tissue has occurred to a considerable extent causing both bones to protrude. As the distal tissues have contracted from the original surface of the wound, the old skin has been drawn nearer to the bones, thus decreasing the exposed surface covered only by epithelium and giving the macroscopic appearance of old skin pinching in over the wound. Figure 4 shows the protrusion of bone and the decreased surface of the wound. A few mesenchymal cells are found under the epithelium and the line of dedifferentiation is clearly indicated running from the limit of the old skin in toward the bone. Beyond this line breakdown does not occur. Bone, as seen extending through the middle of the figure, is not dedifferentiating.

In the tail, bone does not protrude; consequently, the surface of the wound is not reduced. Beneath the epithelium there is a great accumulation of mesenchymal cells. Thus, there is a distinct difference between the tail and limb at this stage. The tail with its large wound surface has undergone much more dedifferentiation with consequent formation of mesenchymal tissue.

Case 7, fixed 8 days after amputation. In the limb there is a greater concentration of mesenchymal cells than is present in the 6-day stage but not as great as in the tail. The tissues have swollen to almost their original position before shrinkage occurred. However, due to that shrinkage, old skin has remained closed in at the periphery of the wound. Figure 5 illustrates the rounding up of the stump of the limb and the increase in mesenchymal cells. The surface of the wound not covered by old skin extends only ½ inch to either side of the bone in the figure. The skin ends where it comes in contact with the black scab. Dedifferentiation is occurring only beneath the epithelium and extends only a short distance back from the surface and bone is still not breaking down.

In the tail the mesenchymal cells have increased greatly in quantity forming the young blastema which extends beyond the end of the bone. This is very different from conditions in the limb where bone extends through the mesenchymal cells of the potential blastema.

Case 8, fixed 12 days after amputation. In the limb one bone is covered by old skin while the other bone still protrudes. The actual surface of the wound not covered by skin is small. Although the accumulation of mesenchymal tissue is considerable, it can hardly compare with the quantity in the tail. There are indications of the differentiation of blood sinuses and collagen fibers in the blastema. The fibers are lining up to become continuous in concentric arcs with the contours of the epithelium and old skin.

Figure 6 shows the old skin on the right extending over the end of the bone. To the left in the figure, the surface of the wound not covered by skin is very slight and between the bones there is only ½ inch of wound surface. Dedifferentiation occurs about ½ inch back from the surface. (Compare with fig. 7 of tail). Figure 10, of the limb, is a higher power view of the section used for figure 6 taken where breakdown has occurred and mesenchymal tissue has formed. The black masses (lower left and upper right) are muscles and the faint mass in the center is muscle undergoing dedifferentiation. (Compare with fig. 11 of the tail.)

In the tail, the blastema is further developed. Collagen fibers are not present among the mesenchymal cells, but blood sinuses are forming and there are indications of the differentiation of other tissues in the blastema. Figure 7, of the tail, shows that the surface of the wound is entirely free from old skin. Compared with figure 6 of the limb it can be seen that at this stage many more cells are present in the blastema of the tail than in that of the limb. Dedifferentiation occurs about 1½ inches back from the surface of the tail, whereas it occurs only ½ back from the surface of the limb. The dense accumulation of cells at the end of the bone is the beginning of the cartilaginous tube formation normal in tail regeneration. Old bone does not extend through the mesenchymal cells as it does in the limb (fig. 6). Figure 11, of the tail, is a higher power view of the section used for figure 7 taken in a dedifferentiating region to show mesenchymal cells similar to those in the limb (fig. 10). Striated muscle which is breaking down into mesenchymal cells is shown in the upper right hand corner. The black cells, lower left, are pigment cells.

Case 9, fixed 17 days after amputation. In the limb both bones are covered, one by skin, the other by epithelium. Skin spreads over all but a very small area of the original wound surface. Only two tissues are now differentiating from the mesenchymal cells: dense connective tissue in which collagen fibers predominate and cartilage. Figure 8 shows the small skin-free surface. The extent of the scales indicates the limit of the old skin. Fibrous scar tissue exists in concentric arcs beneath the epithelium and very little or no dedifferentiation is occurring. The black oval, to the left in the figure, is bone capped by new cartilage. Figure 12 is a higher power view of the section used for figure 8. On the right are collagen fibers lined up beneath the epithelium and the black mass, lower left, is bone with cartilage cells above it.

In the tail collagen fiber is forming but not to an abnormal extent as in the limb. There is no old skin covering the surface and a great amount of differentiation is occurring. Figure 9 shows the old skin in its original position. A little dedifferentiation is still taking place in the proximal portion of the blastema while differentiation is going on in the distal portion. Figure 13 is a higher power view of the section used for figure 9 to show differentiation. In the lower part of the photograph, cells are aggregating to form the cartilaginous tube. About one-third of the way down from the top of the figure is a new blood vessel. Breakdown of bone, upper right, is occurring.

Comparing differentiation in the limb and tail at this stage, the process is further advanced in the former but fewer tissues are forming.

Case 10, fixed 43 days after amputation. In the limb whole skin completely covers the original surface of the wound. Large cartilaginous masses cap the ends of the bones and collagen fibers have formed thick scar tissue. No breakdown is occurring and very few mesenchymal cells are present (fig. 14).

In the tail the blastema is greatly enlarged and much differentiation has occurred. Striated muscle has formed between the epithelium and cartilaginous tube. This tube containing the nerve cord is continuous with the vertebrae and extends to the distal tip of the regenerant. Blood sinuses and new vessels are abundant. A dermal layer is present in the regenerant only at the proximal end where new skin is folding to form scales. The differentiation of collagen fiber has not been at all extensive as in the limb, and mesenchymal cells are still present distally (fig. 15).

Additional microscopic observations

There are differences between the skin and muscles of the two regions that may explain why the tissues of the limb shrink while those of the tail remain in their original position after amputation. The skin of the tail is stiff, due to the hard scales, and fibers connect the dermal layer tightly to the muscles. There are more muscles more compactly arranged in the tail than in the arm. The muscle bundles occur in an orderly pattern forming 45° angles where their proximal ends attach to the vertebrae. The distal ends are joined by connective tissue with the dermal layer of the skin. This arrangement plus the stiff skin can support the tissues of the tail after amputation and inhibit shrinkage.

In contrast, the skin of the limb is flexible and loosely attached to the underlying tissues. Beneath the dermis there are large lymph spaces in the subcutaneous tissue. The muscles are not arranged in an orderly pattern. They either run parallel to the bones or their proximal ends are joined by connective tissue with the skin while their distal ends are attached to the bones. This arrangement of muscle covered by loose skin permits shrinkage of the limb tissues after amputation.

DISCUSSION

The initial healing after amputation of the limb and tail of a lizard is similar. A scab forms, epithelium spreads over the surface of the wound and dedifferentiation beneath the epithelium results in the production of mesenchymal cells. However, by the end of the first day of healing, differences between the two regions become visible. The first difference is the decrease in the limb, of the skin-free surface of the wound. Three days after amputation the area of wound surface is slightly reduced due to shrinkage of tissues distally which brings old skin closer to the bones. The area is further decreased with time until skin completely covers the stump. The area of wound surface in the tail is never decreased.

Correlated with this first point are the results of experiments by which partial regeneration of a limb of a lizard has been obtained. Marcucci ('26) and Guyénot and Matthey ('28) increased the surface of the wound of a hind limb to an area greater than that obtained by simple amputation by amputating the limb in such a way as to wound the thigh and tail. Partial regeneration was also induced in limbs of lizards by Guyénot and Ponse ('30) who, prior to amputation, replaced the skin of the limb with skin from the tail. Possibly the stiffer tail skin inhibited shrinkage of the tissues in the limb thereby maintaining the original surface of the wound, as normally occurs in the tail.

The second difference in healing between the limb and tail has to do with the extent of dedifferentiation and the resulting amount of mesenchymal tissue. The extent of dedifferentiation seems to be dependent on the size of the skin-free surface of the wound. There is deeper breakdown beneath a large wound surface than beneath a small one. Mesenchymal tissue, in turn, increases in proportion to the extent of dedifferentiation. There are more mesenchymal cells where there has been extensive breakdown than where little dedifferentiation has occurred. Therefore, when the tissues of the limb shrink, reducing the surface of the wound, the extent of breakdown is diminished and, correspondingly, the amount of mesenchymal tissue is reduced as compared with the tail. The quality of dedifferentiation and mesenchymal tissue is the same in both regions, but the quantity in the tail greatly exceeds that in the limb.

The third difference is in the type of differentiation of the mesenchymal cells. In the limb, chiefly connective tissue and cartilage are formed, whereas in the tail all the tissues are produced. The scarcity of mesenchymal cells, as compared with the quantity in the tail, may be responsible for the differentiation of only two tissues in the limb. Another condition resulting from the shrinkage of tissue may also influence differentiation in the arm. This is the presence of dermis and bone in the potential blastema, a condition not found in the tail.

All the conditions mentioned above which cause the healing in the limb to differ from that in the tail result from the original shrinkage of tissue or, at least, may be directly correlated with that shrinkage. Therefore, inhibition of regeneration in the limb of a lizard may be attributed to that process which decreases the skin-free surface of the wound. If the conditions causing the healing of the limb to differ from that of the tail could be eliminated, it seems probable that the limb would regenerate. Work along this line has been started but has not yet been completed.

SUMMARY

1. Wound healing and regeneration in fore-limbs and tails of lizards were studied macroscopically and microscopically.
2. The limb of the lizard does not regenerate after amputation, whereas the tail does.
3. During healing the surface of the wound in the limb is decreased when the distal tissues shrink leaving the bones protruding and bringing the old skin nearer to the bones. In the tail the old skin always remains in its original position and the surface of the wound is never decreased.
4. In the limb, following the decrease in wound surface, there is little dedifferentiation and, consequently, few mesenchymal cells, as compared with the tail.
5. Shrinkage of tissues in the limb brings dermis of the old skin and bone into contact with the differentiating mesenchymal cells. This condition does not exist in the tail blastema.
6. Although dedifferentiation in both regions results in mesenchymal cells, differentiation in the limb produces only connective tissue and cartilage, while in the tail it produces numerous tissues. This

may be due to the smaller number of mesenchymal cells in the limb and/or the presence of dermis and bone in the blastema.

7. In the stump of the limb the blastema is transformed to scar tissue and to cartilage around the cut ends of the bones, while in the tail it differentiates into a new tail replacing the one lost at amputation.

8. Regeneration in the limb of a lizard is probably inhibited by the decrease in a skin-free wound surface and the resulting conditions of this process.

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PLATE 1

EXPLANATION OF FIGURES

1 Fore-limb 1 day after amputation. × 16.
2 Tail 1 day after amputation. × 16.
3 Tail 3 days after amputation. × 16.
4 Fore-limb 6 days after amputation. × 16.
5 Fore-limb 8 days after amputation. × 16.
6 Fore-limb 12 days after amputation. × 16.
7 Tail 12 days after amputation. × 16.
8 Fore-limb 17 days after amputation. × 16.

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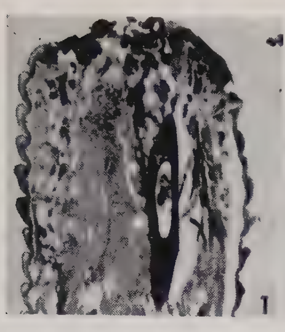
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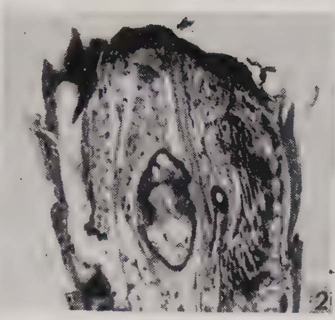
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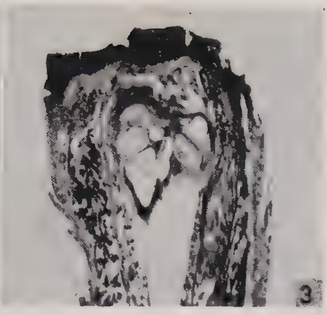
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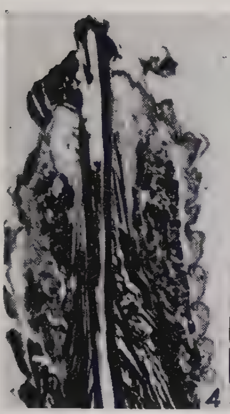
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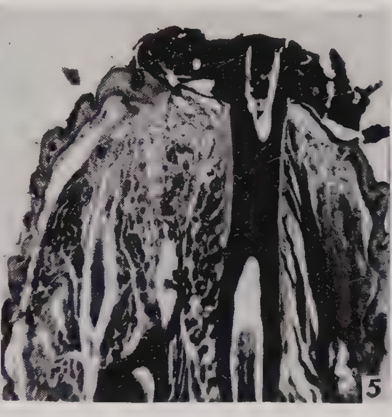
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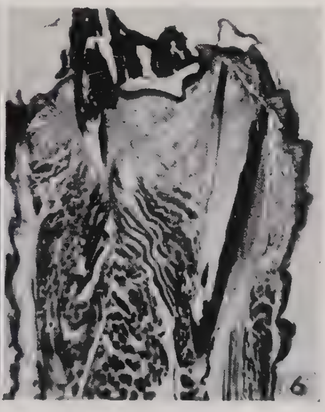
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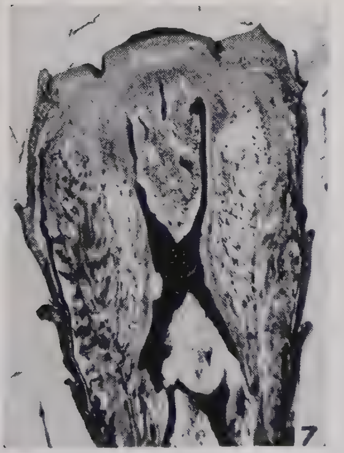
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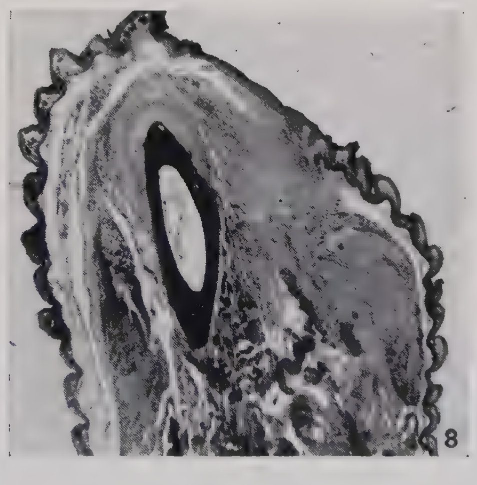
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PLATE 2

EXPLANATION OF FIGURES

9 Tail 17 days after amputation. × 16.
10 Fore-limb 12 days after amputation. × 192.
11 Tail 12 days after amputation. × 192.
12 Fore-limb 17 days after amputation. × 192.
13 Tail 17 days after amputation. × 192.
14 Fore-limb 43 days after amputation. × 16.
15 Tail 43 days after amputation. × 16.

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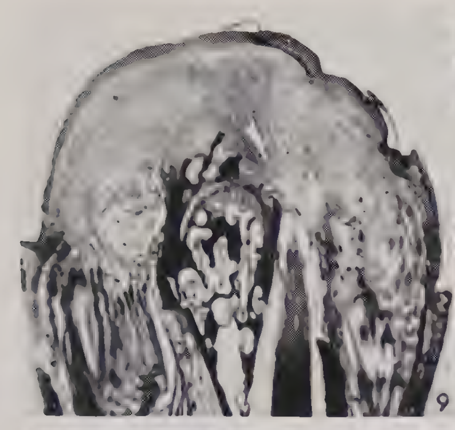
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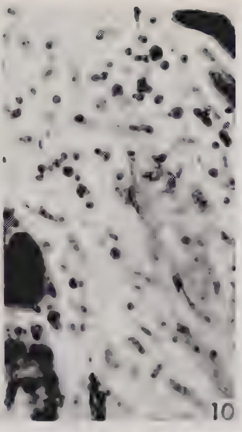
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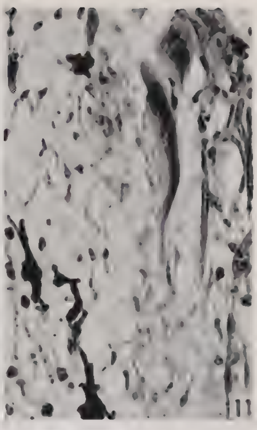
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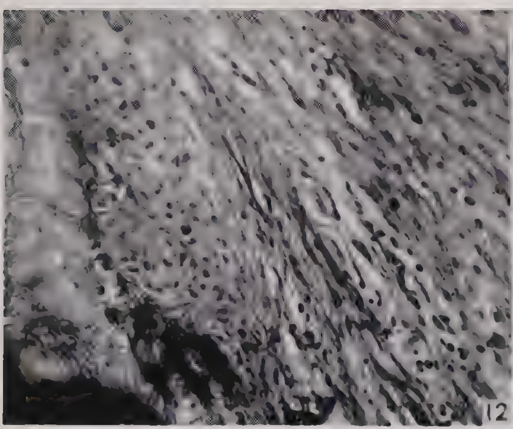
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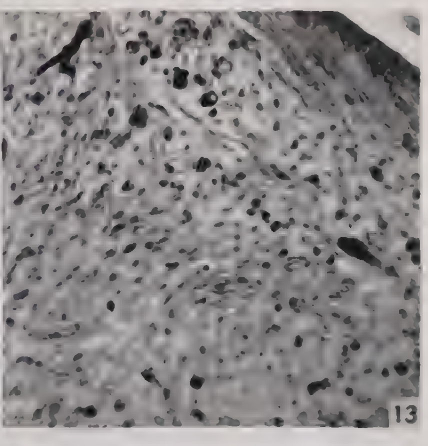
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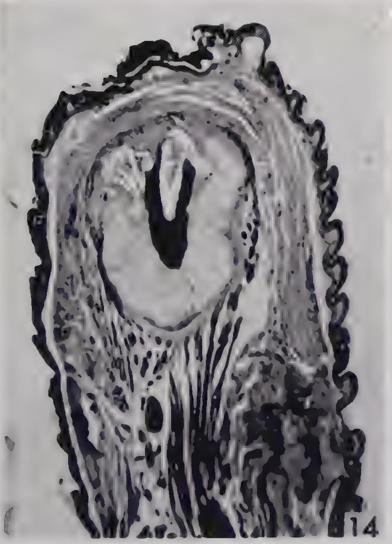
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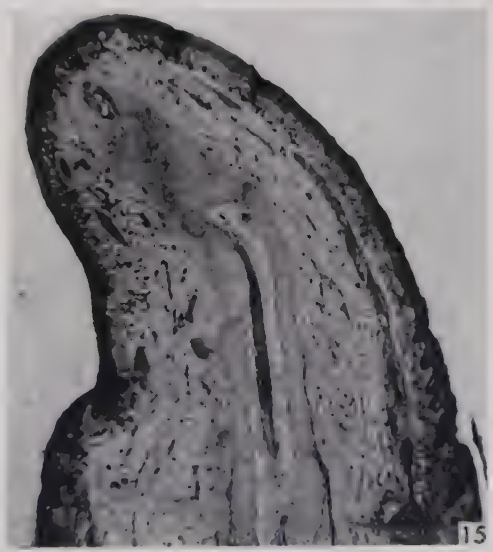
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SIZE OF THE VULVA IN THE FOX AND ITS RELATION TO FERTILITY

OLIVER P. PEARSON AND CHARLES F. BASSETT
Fish and Wildlife Service, United States Department of the Interior, and Edward Martin Biological Laboratory, Swarthmore College, Pennsylvania

FOUR FIGURES

The vulva of the fox increases in size and tumescence as estrus approaches and is a fairly reliable indicator of the sexual condition of the vixen (Bassett and Leekley, '42). The greatest size is reached and regression begins 1 or 2 days before the female becomes receptive. Since 1936 the vulva of each silver fox vixen (Vulpes fulva) at the U. S. Fur Animal Experiment Station, Saratoga Springs, New York, has been examined at regular intervals during the estrous and proestrous periods, and the size and condition recorded. Since vulvar size was relied upon to a large extent to indicate when a vixen was ready to mate, observations were particularly careful and frequent during the period just before estrus, which is also the period of maximum size.

From 1936 through 1939 the vulvar size was recorded by verbal description such as: slightly swollen, large, badly swollen, etc. From 1940 through 1943 an arbitrary system of numbers was applied to the various vulvar sizes. These numbers were based on the sizes of a set of wire rings, slightly heart-shaped, which ranged from size 1 ($\frac{5}{16} \times \frac{8}{16}$ inches) to size 9 ($\frac{14}{16} \times \frac{18}{16}$ inches). When taking measurements a ring sufficiently large to barely enclose the entire vulva was used, the pointed end always being applied to the ventral portion to insure uniformity of measurement. Originally the examiner carried the wire rings and used them as guides in determining the vulvar size, but after experience had been gained in "freehand" estimation, the rings were used infrequently. Size 3 ($\frac{7}{16} \times \frac{10}{16}$ inches) was the smallest encountered during the breeding season, and size 9 the largest — a range of seven groups. The difference between any two consecutive sizes was so small ($\frac{1}{16}$ of an inch) that there were frequent borderline cases, some of which may have been included in the wrong size group.

The early descriptive records (1936–1939) were later transposed into the numerical system. This transposition was not entirely smooth because the numerical system was divided into more size groups than the descriptive system, and therefore, very few additions were made to certain of the numerical size groups. It was considered advisable, however, to combine the two groups in approaching some of the problems, because this nearly doubled the number of observations available. Each vulvar size referred to in this paper is the maximum reached by a particular vixen in the breeding season under consideration, and is not the vulvar size at the time of mating.

The vulva of a yearling vixen seldom becomes as large as that of an adult, although the yearlings are quite capable of reproducing (Bassett and Leekley, '42). The mean maximum vulvar size and probable error of 115 yearlings that mated during 1940–1943 was 5.42 ∓ .06, with a standard deviation of .98 sizes. The mean maximum vulvar size preceding 190 adult estrous periods during the same time was 6.60 ∓ .05, with a standard deviation of 1.11 sizes.

To eliminate the possibility that yearlings with small vulvas were not kept until they became adults, which would make the adult average appear larger, the vulvar size was traced in fifty-four vixens that had been kept for 3 years during the 1936–1943 period. The mean vulvar sizes of these vixens in each of their first 3 years were 5.72 ∓ .09, 6.52 ∓ .10, and 6.72 ∓ .10, respectively. The difference between the yearling and second year is easily significant; that between the second and third year is not statistically significant, although additional data might prove it to be so.

Furthermore, it was found that there was a correlation between the maximum vulvar size of an individual vixen in successive years. The coefficient of correlation between the maximum vulvar size in the yearling year and the adult years for 115 vixens from 1936 through 1943 was + .42 ∓ .04. This means that if the vulva reached a large size in the yearling season, relative to the other yearlings, there was a considerable tendency for it to reach a large size in later seasons, relative to the other adults. Similarly, a vixen with a small vulva during her first breeding season was likely to have a small vulva in subsequent seasons.

THE RELATION BETWEEN VULVAR SIZE AND FERTILITY

Figure 1 shows the relation between vulvar size and the mean number of pups per mated female. All mated vixens are represented in the graph, including those that did not become pregnant, and those that aborted or resorbed their embryos. Vixens that whelped and then destroyed their litters were counted as non-producers. Dotted lines were used in figure 1 when an average was compiled from fewer than ten cases. It is obvious that there was a close relation between vulvar size and fertility among adults and among yearlings. Each increase of one vulvar size was associated with an average increase of .75 pups per mated female among the adults, and .45 pups per yearling female. The regression equations are:

$$\text{number of pups per mated adult female} = .75 \times \text{vulvar size} - 2$$
$$\text{number of pups per mated yearling female} = .45 \times \text{vulvar size} - .7$$

In figures 2, 3, and 4 the data in figure 1 have been broken down to determine what reproductive process is responsible for the close relationship between vulvar size and fertility. Figure 2 treats those vixens that raised litters, and shows the relation between vulvar size and the number of pups per litter. Usually the pups were counted when they were about 7 days old. It is apparent that there was a slight tendency for vixens with large vulvas to have large litters. The coefficient of correlation between size of vulva and size of litter for the adults, using the same data that were incorporated in figure 2, was $+ 15 \mp .05$, and for the yearlings, $+ .31 \mp .07$. These are not high correlations, and their statistical significance is questionable. Certainly the correlations are not high enough to explain entirely the close relation shown in figure 1.

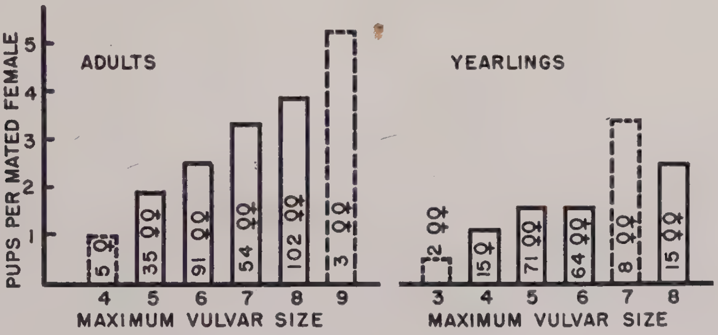

FIGURE 1

Figure 3 shows the relation between maximum vulvar size and the per cent of mated vixens that failed to whelp. A negative correlation is readily apparent among the adults, but is not as distinct in the graph of the yearlings. Failure to whelp may be due to a number of causes such as: failure to ovulate, failure of fertilization or implantation, abortion, or resorption of embryos. Since we do not know which of these factors were responsible for the failures that occurred, it is impossible to say which were responsible for the trend shown in figure 3.

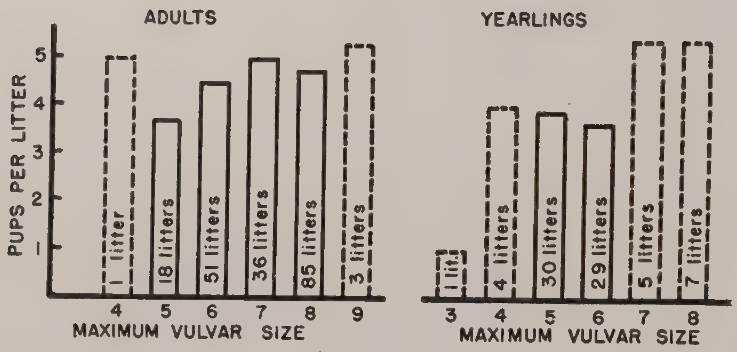

FIGURE 2

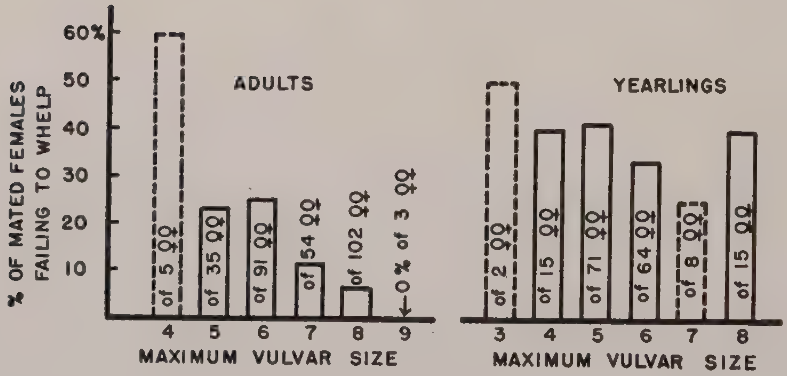

FIGURE 3

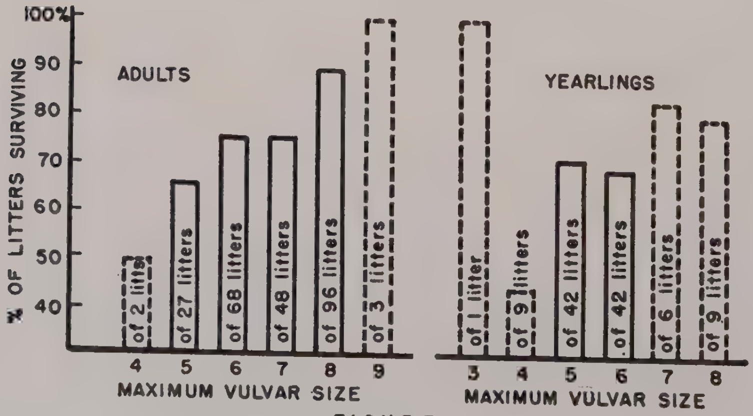

FIGURE 4

It may be seen in figure 4 that there was a close relationship between vulvar size of the mother and the per cent of litters that survived after birth. In most, if not all, of the cases where the litters failed to survive, they were killed during their first week by the mother. This destruction of litters occurs widely among ranch foxes; its cause is unknown. The survival of litters whelped by adult vixens increased by 9% for every increase of one vulvar size. Among the yearlings, each increase of one vulvar size was associated with a 7% greater survival of litters. The regression equations are:

$$\text{survival of litters (in per cent) whelped by adults} = 8.8 \times \text{vulvar size} + 19$$
$$\text{survival of litters (in per cent) whelped by yearlings} = 7.5 \times \text{vulvar size} + 26$$

In conclusion, the data show that vulvar size was related to the number of pups per mated female, to failure to whelp, to the survival of litters, and probably to litter-size. Superior performance was associated in each case with large vulvar size.

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A CYTOLOGICAL STUDY OF THE SECRETION ANTECEDENTS OF RAT THYROIDS ACTIVATED BY THIOUREA

OWEN LEWIS THOMAS
Department of Anatomy, Otago University, Dunedin, New Zealand

TWO PLATES (SIX FIGURES)

INTRODUCTION

Morphological evidence in the cells of the thyroid gland of a secretion antecedent in the form of a cytoplasmic precursor or series of precursors of the substance secreted, has often been sought. Of the earlier communications on this subject, the most outstanding in that it established the classical theory of thyroid secretion, was that of Bensley ('16). By a specific staining technique, this worker was able to identify a vacuolar substance at the extreme base of the follicular cells adjacent to the capillary net, and he believed that this substance is discharged directly into the blood stream and that this represents the normal direct mode of secretion of the thyroid gland. To account also for the presence of both intracellular and intrafollicular colloid he postulated further an indirect method, whereby the secretion is condensed in the cell cytoplasm into droplets with a high content of solids (colloid droplets), which are then extruded into the follicular cavity; and that this alternative process occurs when the rate of secretion exceeds body needs.

Although Bensley observed the vacuolar substance in the thyroids of hibernating opossums as long ago as 1916 his claims do not appear to have been fully substantiated in other animals. Recently however, de Robertis ('41) using the freezing-drying technique of Altmann-Gersh has studied in the rat both normal glands and glands activated by thyro-tropic hormone and has stated:

> Very rare in normal glands, but more conspicuous in activated ones is the disposition of the colloid in basal vacuoles. This basal colloid stains a very light blue and sometimes has a granular structure due to a fine ice crystal formation. It is apparently a more fluid colloid, similar to that described by Bensley in the opossum. It generally appears in one big vacuole near the basal border, pushing the nucleus

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toward the centre of the cell. The presence of this basal colloid especially when the secretory activity of the thyroid cell is greatly increased, seems to indicate that it is secreted towards the basal pole of the cell.

In a second paper ('42) he analysed the effects of a single large dose of thyrotropic hormone upon the thyroid cells, and again observed the basal dilute colloid, correlating its appearance with the earlier phases of stimulation by the hormone. However, de Robertis apparently did not control these experiments by staining his material with Bensley's original specific technique, and his identification of the pale staining basal colloid with the basal vacuolar substance of Bensley, appears therefore to be purely presumptive.

As further confirmation of the possible occurrence of Bensley's vacuolar substance seemed desirable I investigated with this end in view both normal rats and rats activated with diets including Brassica seeds (Hercus and Purves, '36) using Bensley's original technique. In these experiments however since I was only able to identify the pale staining basal vacuoles in occasional follicular cells and then only in a few instances, I began to doubt whether Bensley's substance occurs in these animals. I attempted then to confirm the results obtained by Bensley, by studying, again with his method, the thyroid of the Australian opossum (Trichoscrus vulpecula) but here also the cells of the gland showed no basal vacuolar substance. As it seems that the Australian opossum in New Zealand never hibernates, I concluded that the phenomenon described by Bensley must depend upon the metabolic conditions in hibernation, and that, if the basal substance was indeed a true secretory antecedent it must be accumulated in the quiescent state of hibernation. Its absence then in the rat might be explained by the fact that its elaboration and discharge go on simultaneously and the opportunity, under normal conditions, of its storage within the cells does not occur. Such an explanation might well account for the absence since 1916 of any satisfactory report of the basal antecedent, although it should be pointed out that Key ('25) claimed to have identified the substance in human material; his description however is unconvincing and his view that the cells are in fact in a state of cytoplasmic degeneration had already been foreseen and adequately countered by Bensley in his original communication. Baillif's ('37) account is even less convincing since the fixation of his material was obviously unsuitable. Ulenhuth ('24) working with Salamander material dismissed the view that the Bensley substance is a new form of secretion antecedent and claimed that the Bensley cells discharge their contents into the lumen of the follicle and collapse to become Langendorff's cells.

The recent discovery by Kennedy ('42) of the potent thyro-activating properties of thiourea at once opened up the possibility of concomitant cytological changes in the cells of the thyroid gland which might throw light on this debatable question. The only descriptions at present of the histological changes in the thyroid brought about by thiourea are those of MacKenzie and MacKenzie ('42) and Astwood et al. ('42) who record with no cytological detail, marked epithelial hyperplasia and great reduction of the intrafollicular colloid. The conclusion of Astwood et al. "that the resultant thyroid hyperplasia which occurs is considered to be compensatory to the failure of thyroid hormone synthesis", further encouraged me to hope for some obvious cytological evidence of the secretory antecedent in glands which had been activated by thiourea. I therefore redirected my attention to determining whether Bensley's basal substance is identifiable in the rat under such conditions.

METHODS

Wistar strain rats were kept at a room temperature of 75°–85°F. on a diet of maize and wheat supplemented with small pieces of cheese daily. Thiourea was added to the drinking water at a concentration of 0.25%. The animals were killed by coal gas usually between the tenth and twentieth day. The thyroids were quickly removed and alternate lobes fixed as follows:

1. Zenker stock plus 10% formol prepared by redistilling over magnesium carbonate at atmosphere pressure (Bensley, '38).

2. Bensley's Acetic-Osmic-Bichromate or Flemming with reduced acetic (Gatenby, '37).

The material was embedded after clearing with xylol, according to Gatenby's regime. Staining was as follows:

1. The Zenker material was stained with the Azan standard procedure of Conn ('43) now recommended by Professor Bensley in place of his Brazalin Wasserblau stain ('43). It was found absolutely essential to carry out the differentiation of the nucleal element of the stain until the cytoplasm was quite colourless. At first Brazilin (Gurr or Hartmann) was used as in the original Bensley ('16) technique but the oridinary Azan counterstain proved more consistently satisfactory provided treatment with it was prolonged for 12 hours.

2. The osmic material when treated for 1 hour in 5% phospho-tungstic acid, followed by the Azan counterstain gave good contrast pictures of the Bensley's cells.

OBSERVATIONS

Under the influence of thiourea the thyroid gland of the rat becomes hyperaemic and somewhat enlarged. Histologically it shows a marked epithelial hyperplasia and great reduction of the follicular colloid. The lumen of the vesicle frequently is reduced to a slit-like space, with only traces of colloid intervening between the opposing free borders of the follicular epithelium. Such a profound reduction of colloid content is however observed usually only in vesicles which are situated deeply within the gland since the peripheral vesicles tend to be larger and still to contain appreciable quantities of colloid. The perifollicular capillaries are everywhere engorged with red blood cells (fig. 1).

In the majority of vesicles the epithelium is strikingly reduplicated to form, still within the original connective tissue investment of the follicle, cell crescents or nests of an apparently parafollicular nature, Careful study of serial sections shows clearly that certain of these cells are merely ordinary follicular cells lining a small diverticulum of the main cavity (fig. 2). Such ''pseudo-follicular diverticula'' have already been described by de Robertis ('41) in his work on the hyperactive glands of rats, and it seems likely that they are produced by the partial collapse of the follicular cavity which results from colloid withdrawal.

Although occasionally these apparently parafollicular cells do undoubtedly prove to belong to the follicular epithelium proper, the great majority nevertheless after the most careful serial study obviously possess no contact at all with the follicular lumen and are in fact unquestionably excluded from it by the cells of the lining epithelium (figs. 2, 5, 6, 7). True parafollicular cells are therefore beyond any doubt a feature of glands which have been subjected to activation by thiourea. Furthermore as will be explained later observations of suitable sections show convincingly that these parafollicular cells most probably originate from the follicular epithelium itself, by migration from a position in the epithelium to a more peripheral one; an hypothesis which receives additional support from the fact that these parafollicular cells never show mitoses whereas they are frequently seen in the follicular epithelial cells proper.

Bensley's basal vacuolar substance

Under the influence of thiourea, Bensley's basal vacuolar substance becomes strikingly apparent. It can be seen distinctly in the follicular cells occupying a position usually on the basal side of the nucleus (fig. 3), although occasionally it may extend centrally so as partly to surround it. In well fixed cells it appears most often as a clear hyaline spherule generally of considerable size although sometimes it may take the form of several globules separated by fine cytoplasmic bridges (fig. 5). Besides a profusion of granular mitochondria aggregated towards their outer poles, the cells may occasionally show a few deeply stained colloid droplets in a more central position. With the staining methods described whereas the basal substance appears a very pale blue such intra-cellular colloid droplets on the contrary are observed to be dense blue or red. Since their nuclei are never pycnotic the cells are easily distinguishable from Langendorff "colloid" cells which have markedly pycnotic nuclei; moreover Langendorff cells are seldom found at the height of cell hyperplasia.

In some cases in which the basal vacuoles are large, their contents show shrinkage resulting in the occurrence of secondary vacuoles at the periphery of the main one (fig. 2, v.), which thus comes to resemble in miniature a follicle with vacuolated colloid, and to suggest strongly the entity of the basal substance as a cytoplasmic inclusion.

In his account of the vacuolar substance in the thyroid of the opossum, Bensley ('16) observed that in favourable material it collected in all the cells of the gland. In the rat its occurrence is not so widespread since relatively few of the cells of any one follicle show it convincingly. Among the true parafollicular cells however it is much more commonly encountered since the majority of these cells are seen to be almost full of basal substance (fig. 5). Their cytoplasm is reduced to thin strands ramifying between the vacuoles, around the nucleus, or at the periphery of the cell, forming in fact a delicate spongework. The staining reactions of the vacuolar content in these parafollicular cells are identical with those of the basal cells of Bensley in the follicular epithelium, a fact which strongly suggests that the parafollicular cells may actually have migrated from the lining epithelium upon accumulating vacuolar basal substance. This view is further reinforced by the fact that numbers of basal cells can be observed apparently in the process of migration since they frequently present a slender prolongation of their cytoplasm towards the follicular lumen, and by means of which they retain contact with the intrafollicular colloid; while their basal portion replete with vacuolar substance is quite divorced from the adjacent epithelium (fig. 5). More frequently still basal cells may be seen at what appears to be a later stage in their withdrawal for a delicate strand of their cytoplasm can be observed to extend for some distnce between the adjacent follicular cells which appear to have approximated to bridge the deficiency left by the migrating cell (fig. 6).

In preparations prepared with osmium fixatives, and stained with aniline blue-orange G, Bensley's cells are very obvious, particularly when they are parafollicular in position. Apparently osmium results in a diffusion of the vacuolar substance throughout the cytoplasm so that the cells stain more evenly blue and are thus strikingly differentiated from the cells of the follicular epithelium itself. This marked distinction of the two types (fig. 2), might indeed almost excuse the misrepresentation of the basal cell as a new type of epithelial element within the gland.

The intracellular colloid droplets

Intracellular colloid droplets appear within thyroid cells activated by thiourea. They vary from minute closely aggregated granules to fairly large discrete droplets which with the above techniques stain distinctly either dark blue or red. With iron haematoxylin however they become an intense black in contrast to the vacuolar basal substance which is merely tinged a faint gray shade and is hard to differentiate from the surrounding cytoplasm. Frequently these intracellular colloid droplets appear in rows between the two poles of the cells, apparently forcing the nucleus to one side (fig. 4) a form of dispersion of the droplets previously described by de Robertis ('41) and interpreted by him as probably representing a transcellular release of colloid from the follicular cavity to the base of the cell. I was not able however to confirm his report of the coexistence in the one cell of this appearance with the presence of basal substance. In cells storing basal substance some small colloid droplets may occasionally be seen but they are then usually situated towards the central pole of the cell, which accords rather with Bensley's indirect mode of secretion. It is perhaps unfortunate that de Robertis in both of his papers has referred to Bensley's vacuolar substance as a ''dilute colloid.'' In view of what we know at present of this material the use of de Robertis' term is to say the least extremely confusing. The term ''Bensley's basal substance'' is obviously preferable since it is clearly distinguishable from the intracellular colloid droplets in its fixation and staining reactions and the interrelation of this substance with the colloid droplets is at present unsupported by adequate evidence (Cowdry, '38).

The argentaffins of Nonidez

Nonidez ('32) called attention to the presence of argentaffin parafollicular cells in puppies and rabbits. In view of the possibility that the parafollicular cells which I have observed might represent such cells, experiments were carried out using Nonidez' technique on my material. A number of Cajal variants, Bodian's ('36) and Holmes' ('43) silver techniques were also tried. All of these failed to reveal the presence of any argentaffin cells in the rat thyroid. It was however observed that mast cells in the interfollicular connective tissue sometimes had their granules electively stained by silver.

I was forced to the conclusion therefore that the Bensley's basal cells could not be identified with the argentaffins of Nonidez.

DISCUSSION

The results described not only present evidence of the accumulation of Bensley's substance in the thyroid of rats influenced by thiourea, but also suggest strongly, that cells which have accumulated this substance proceed to migrate from the follicular wall to a parafollicular position. While the mechanism of such migration is not at all clear, it might well depend upon physical stresses arising in the hyperactive gland, possibly in conjunction with alterations of the cell density from the accumulation of the basal substance. Alternatively an active migration of these cells cannot be excluded, and is indeed supported by the fact that the parafollicular basal cells always possess an intimate relation with the perifollicular capillaries, a relationship which might certainly facilitate the discharge of their burden into the blood stream.

It would appear then that thiourea produces in the thyroid gland of rats a change, resembling that set up during hibernation in the opossum. In both cases there is an accumulation within the cytoplasm of a substance which seems to be almost certainly a secretory antecedent stored within the cell to excess. Similar excessive accumulations of the antecedent substance also occur as we have seen when the rat thyroid is stimulated by large doses of thyrotropic hormone (de Robertis, '42). Under such conditions some cells are so charged with this substance that, according to de Robertis, "they look like a sponge whose spaces are filled with dilute colloid" (i.e. Bensley's substance). As the stimulus of the hormone dies away however, there is a marked reduction in the basal vacuoles. Under such circumstances it would seem that the appearance of this substance is an expression of the profound stimulation by thyrotropin. Although cells receiving this stimulus are secreting to their utmost, the antecedent nevertheless appears to be produced at even a greater rate, and beyond the capacity of the cell membrane to pass it on to the capillaries. Thus there is brought about the transient accumulation of a visible inclusion within the cytoplasm.

As the thyrotropic stimulus falls the evidence suggests a parallel disappearance of the substance from the cell.

In the case of thiourea on the contrary, it is known that the actual secretion of thyroxin by the gland is minimal (MacKénzie and MacKenzie, '42; Astwood et al., '42), in spite of its generally hyperactive appearance. Nevertheless the cytological picture closely resembles that resulting from thyroptropin administration. The functional disparity, together with the similarity in cytological appearances suggests that the changes due to thiourea must therefore depend upon some mechanism which prevents the release of the antcedent from the cell and which may well be due to some alteration in the permeability of the cell membrane. In this way the secretory antecedent could accumulate gradually within the cytoplasm producing the same cytological picture as that observed by Bensley and de Robertis but one having a quite different significance. In other words the antecedent has a totally different secretory potentiality in the two cases.

That the normal colloid withdrawal mechanism on the other hand is in no way way impaired by thiourea is indicated by the marked loss of intrafollicular colloid and the occurrence within the cells of intracellular colloid droplets in the phase of transcellular release.

If then we accept the prevailing view as to the nature and significance of these cytological inclusions we may justifiably conclude that thiourea acts by paralysing basal secretion, without affecting withdrawal of stored colloid from the thyroid gland.

SUMMARY

1. Activation of the thyroid gland of rats by thiourea, results in the accumulation within the cells, of a cytoplasmic inclusion identifiable with the basal vacuolar substance of Bensley.

2. The formation of true parafollicular cell nests is described. Evidence is put forward which suggests that these parafollicular cells are derived from the Bensley's cells of the follicular epithelial lining.

3. It is suggested that thiourea paralyses basal secretion in the thyroid gland, by an alteration of the permeability of the cell membrane to the antecedent secretory substance.

4. Discharge of intrafollicular colloid is unaffected by thiourea and apparently proceeds by the normal process of transcellular release of colloid.

ACKNOWLEDGMENTS

I am greatly indebted to Prof. W. E. Adams for his advice and criticism while drawing up this paper. I am also grateful to Prof.

Hercus D.S.O., O.B.E., for his stimulus in the initial stages of this work and to Dr. Purves and Dr. Griesbach for their constant encouragement and advice. I must also thank Professor Smirk for granting me facilities in the earlier stages.

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ABBREVIATIONS

cap., Perifollicular capillary
p.b.c., Parafollicular Bensley cell
p.f., Pseudofollicular diverticulum
v., Vacuole within a Bensley cell
v.s., Bensley's basal vacuolar substance
c.d., Colloid droplet within a follicular epithelial cell
m.c., Migrating cell
l.l′., Lumina of central (l) and peripheral (l′) follicles
c.t., Interfollicular connective tissue

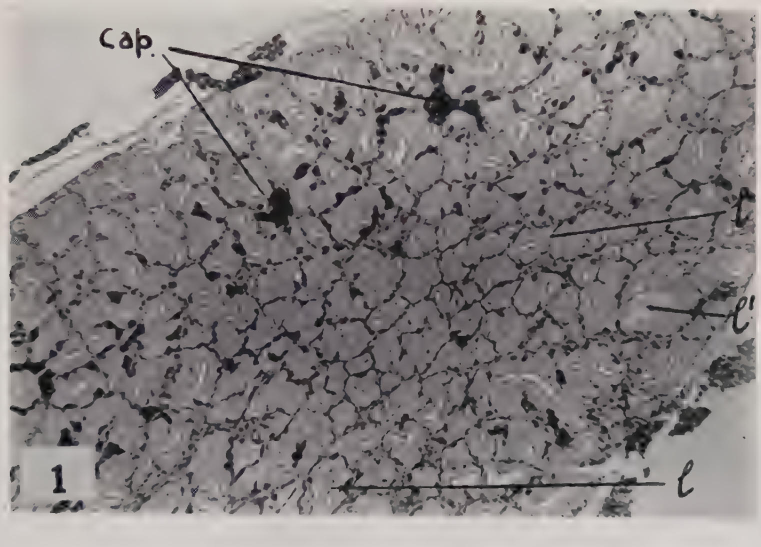
PLATE 1

EXPLANATION OF FIGURES

Figures are unretouched photomicrographs. Figure 1 is photographed with an 8-mm. obj. 6x oc.; figure 2 with a 2-mm. oil im. obj. 6x oc.

1 A low power photomicrograph showing great cellular hyperplasia. Distended perifollicular capillaries are clearly seen (cap.). Centrally placed follicles show great compression of the follicular cavity (l), as compared with that in peripheral follicles (l′). Zenker fixation and Azan staining.

2 A high power view of a compressed follicle clearly outlined by its connective tissue investment (c.t.). Various parafollicular Bensley's cells are seen (p.b.c.). A nest of these can be observed within the follicular boundary in close relationship with a perifollicular capillary (cap.). One isolated parafollicular cell presents a small vacuole (v) within the basal substance. The divorced lumen of a pseudofollicular diverticulum (p.f.) is also seen. Flemming without acetic fixation. Aniline Blue-Orange G stain.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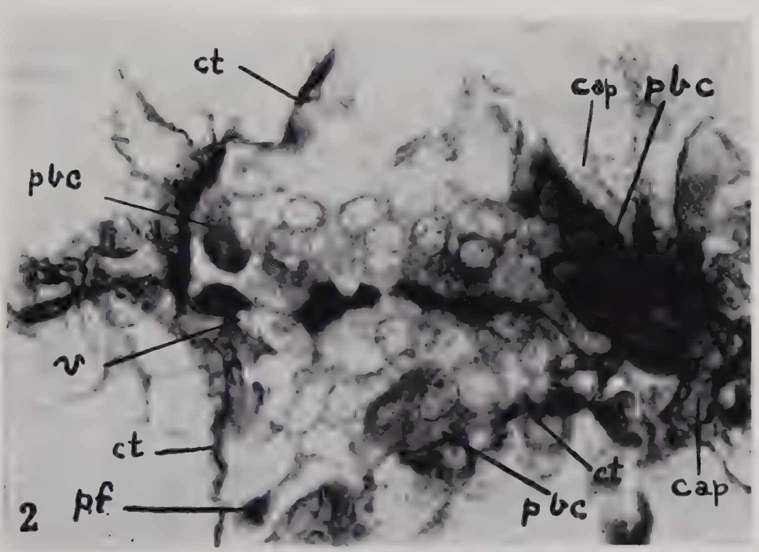
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PLATE 2

EXPLANATION OF FIGURES

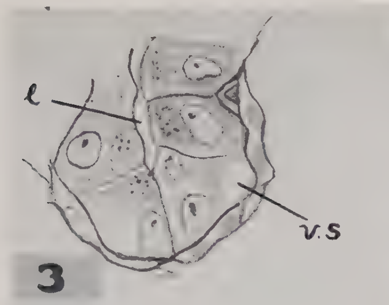
Figures are drawn with the aid of a camera lucida, 2-mm. obj. 10x oc. stage level.

3 Follicle with compressed lumen. Two follicular cells with basal vacuolar substance (v.s.), and centrally aggregated mitochondria are seen.

4 Intracellular colloid droplets (c.d.) within follicular cells. One cell shows droplets in a phase of transcellular release.

5 A portion of a parafollicular cell nest. A basal type cell replete with basal substance apparently in the process of migration from the lining epithelium (m.c.). Two parafollicular basal type cells (p.b.c.) completely full of vacuolar substance, are shown adjacent to the capillary net (cap.).

6 A parafollicular cell at a later stage of withdrawal (m.c.). A thin wisp of cytoplasm extends between the two adjacent cells. Two completely divorced parafollicular cells are also shown (p.b.c.).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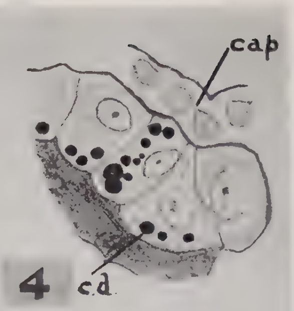
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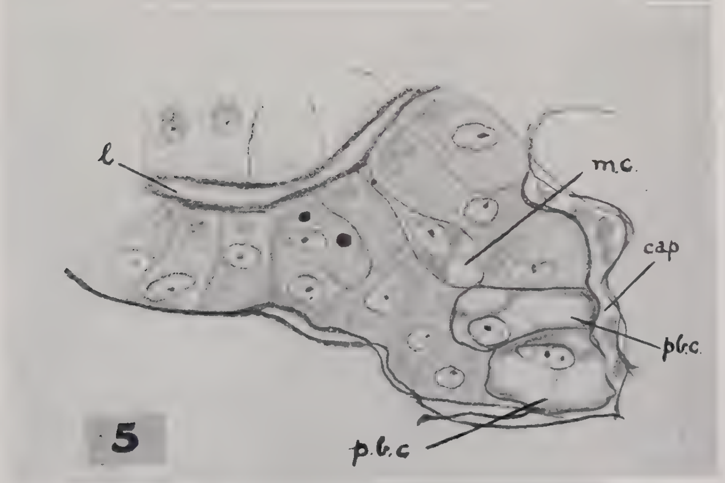
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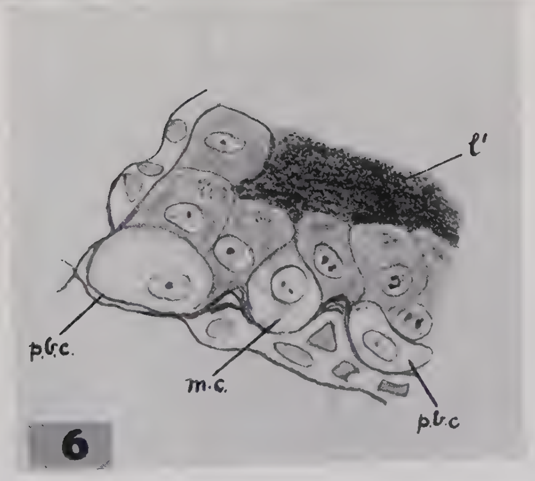
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GENITAL CYCLES FOLLOWING INCOMPLETE OÖPHORECTOMY IN THE CHIMPANZEE[1]

WILLIAM C. YOUNG
Yerkes Laboratories of Primate Biology, Orange Park, Florida, and Yale University School of Medicine, New Haven, Connecticut

TEN FIGURES

The possibility that tissue having the attributes of functional ovaries might develop following complete bilateral oöphorectomy seems to have been considered most likely for a brief period after it was reported that ovarian regeneration occurs following ovariectomy in a small percentage of guinea pigs and rabbits (Castle and Phillips, '11), mice (Davenport, '25; Frank and Goldberger, '26; Parkes and Bellerby, '26; Parkes, Fielding and Brambell, '27) and rats (Hanson and Heys, '27; Pallot, '28). Doubt was soon expressed, however, that the restoration which was reported represented a new formation of ovarian tissue from extra-gonadal sources. Haterius ('28) and Pencharz ('29) concluded that the ovarian regeneration they encountered in the mouse and rat probably could be ascribed to incomplete removal of the ovaries. Heys ('31) expressed the opinion that a similar explanation would account for the six cases of ovarian regeneration previously reported in the rat (Hanson and Heys, '27).

As nearly as the writer can ascertain this conclusion has dominated thought during the past 10 to 15 years and most investigators have regarded the subject as being more or less closed. Our justification for reopening it is that none of the older experiments involved the use of primates and, in view of the fact that the resumption of cyclic genital activity is still occasionally reported following bilateral oöphorectomy in the human female (McArthur, '24; Deutschman, '30; Scott, '36), it seemed that a brief account of a series of experiences with the chimpanzee would be of interest.

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MATERIALS AND METHODS

The animals were members of the Orange Park colony where they had been confined from 3 to 9 years before the observations of sexual and social behavior (Young and Orbison, '44) of which this study is an outgrowth were begun in the fall of 1939. The pertinent details are given for each subject. They show that, although the animals were those whose breeding records were poorest, there were no peculiarities of health, age or cyclic reproductive activity which set them off as a group from the breeding members of the colony.

Kambi. Estimated age at the time of oöphorectomy, 12 years. Used in a study of morphine addiction, February to July, 1937 (Spragg, '40). The normal growth curve and physical appearance suggest that her recovery was complete. First menstruation, July 19, 1938. Thereafter genital swelling and menstruation were somewhat irregular, especially during the winters of 1938–39 and 1940–41 when the preswelling phase was longer than the mean for the colony (Young and Yerkes, '43). Its length, however, was not greater than that in many other subjects during the winter season of the first year or two after the menarche. The period of amenorrhea in 1940–41 preceded the time of the operation by only a few weeks, but development of a normal genital swelling began April 12, 1941. At the time of the operation what appears on microscopic examination to have been a follicular cyst about an inch in diameter and of recent origin was present on the left ovary. Otherwise all parts of the genital tract were normal and freely movable.

Lia. Estimated age at the time of bilateral oöphorectomy, 17 years. Sexual cycles atypical, chiefly with respect to the length of the luteal phase. The mean length of this phase was greater than in any other subject, 14 ± 0.24 days compared with 10 ± 0.06 days for the colony.

May. Estimated age at the time of removal of the second ovary, 16 years. First menstruation, June 11, 1933. Sexual cycles normal. Right salpingo-oöphorectomy, March 24, 1938.

Mimi. Estimated age at the time of removal of the secondary ovary, 18 years. First menstruation, July 18, 1932. Mean length of cycles greater than in any other member of the colony, 46 ± 1.43 days compared with 37 ± 0.14 days for all the females. This is accounted for by longer than average preswelling and swelling phases and menstruations (Young and Yerkes, '43). Left salpingo-oöphorectomy, November 26, 1940.

Nira. Estimated age at the time of bilateral oöphorectomy, 16 years. First menstruation, July, 1933. Sexual cycles normal.

Fixation of the tissues was in chrome-sublimate (Bensley). The sections were stained with Harris' hematoxylin and eosin.

The thirteen operations on the five subjects were performed by Drs. Donald M. Baldwin and F. Gordon King of Jacksonville assisted by Mrs. Baldwin and Mrs. King. The urine specimens from the subject Nira were assayed for estrogenic substances by Mr. William R. Fish. The methods of extraction and assay were the same as those previously employed in a study of the urine from this subject (Fish, Young and Dorfman, '41).

PRESENTATION OF DATA

Protocols containing the history of each of the four subjects in which genital activity was resumed following incomplete oöphorectomy are given below. In order that the cycles displayed during the postoperative period can be compared with those shown prior to the operations, the protocols have been prepared beginning with the fourth complete cycle prior to the removal of the ovaries in the case of Lia and Nira and with the fourth cycle prior to the removal of the second ovary in the case of May and Mimi. The histories are terminated with the permanent suppression of genital swelling and menstruation.

The character of the cycle is indicated by means of the convention adopted by Young and Yerkes ('43) in their analysis of the factors which influence the reproductive cycle in the chimpanzee. Reasons are given in that article for dividing the cycle into four parts, a preswelling phase which is a period of genital quiescence, a swelling phase which corresponds closely with the follicular phase, a postswelling phase which corresponds closely with the luteal phase, and menstruation. When such a division is made the part of the cycle that is affected by age, pregnancy, season and other factors can easily be determined. In the present study something about the character of the cycles after incomplete oöphorectomy can be ascertained by comparing the length of the separate phases before and after the operations.

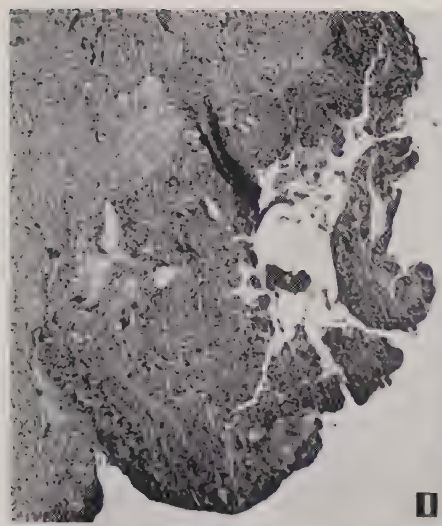
For the reasons given by Young and Yerkes ('43) the first day after menstruation rather than the first day of menstruation is regarded as the first day of the cycle and, except where otherwise indicated, the dates in the left-hand column of the protocols are the dates on which the cycles are considered to have begun. In the five columns of figures on the right of each protocol phase-length and cycle-length are given in days.

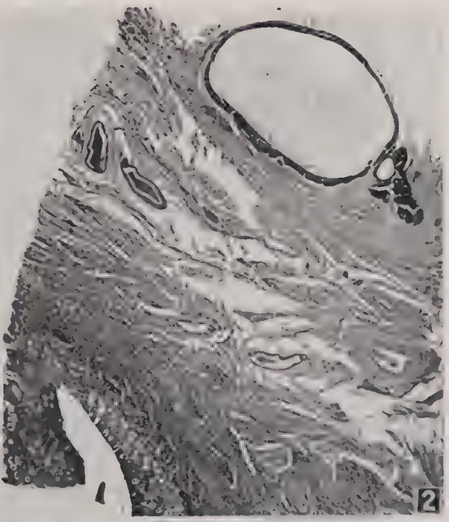
Protocol of Lia

DATES	PRESWELLING PHASE	SWELLING PHASE	POSTSWELLING PHASE	MENSTRUATION	CYCLE
11/18/40	0	14	15	1	30
12/18/40	0	13	15	1	29
1/16/41	1	12	20	2	35
2/20/41	1	16	?	not observed	indeterminate
3/ 8/41–4/4/41	28-day period of genital quiescence				
4/ 4/41	Curettage and endometrial biopsy				
4/ 6/41–4/8/41	Postoperative bleeding				
4/ 9/41	0	10	15	1	26
5/ 6/41	(Second day of cycle and second day of swelling phase). Bilateral oöphorectomy. Ovaries, tubes and uterus were normal and freely movable.				
5/ 8/41–5/10/41	Postoperative bleeding				
5/11/41	79	18	8	2	107
8/26/41	39	16	10	1	66
10/31/41	14	14	12	3	43
12/15/41	(Second day of cycle and first day of swelling phase). Exploratory laparotomy. No adhesions involving the tubes or uterus. Removal of two nodules from right broad ligament near the uterus. In one a small structure bearing some resemblance to an old corpus luteum was found (fig. 1). No postoperative bleeding.				
12/16/41	17	24	?	not observed	indeterminate
1/26/42–2/25/42	31-day period of genital quiescence				
2/26/42	First day of tumescence				
3/ 7/42	(Eleventh day of swelling phase). Hysterectomy. A small adhesion involving the bladder and anterior surface of the uterus was easily separated. A vesicle about $\frac{2}{3}$ cm. in diameter on the anterior surface of the left side of the uterus, midway between the cervix and the utero-tubal junction was later found to contain a graafian follicle and a mass in which luteinized elements were present (fig. 2).				

On microscopic examination of the serially sectioned ovaries removal of the left ovary was found to have been complete. A small portion of the right ovary, on the other hand, appears to have been left behind (fig. 3) and is assumed to have accounted for the display of genital activity which followed ovariectomy. That the fragment was small is clear from the fact that it extended through only 55 of the 273 slides composing the series and from an examination of figure 3 which is a photograph of the ovary at the level where the fragment was largest. The fragment is estimated to have composed less than 1% of the entire ovary and therefore less than one-half of 1% of the ovarian mass present before the operation.

Several features of the case are not clear. The origin of the ovarian tissue in the connective tissue surrounding the myometrium is uncertain. Adhesions would seem to be excluded because when oöphorectomy was performed the ovaries, tubes and uterus were freely movable and during the exploratory laparotomy performed subsequently, no adhesions involving the tubes or uterus were encountered. An alterna-





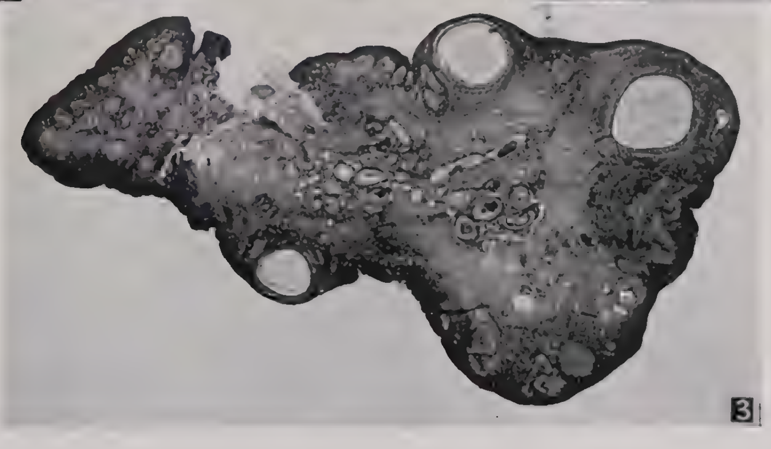


Fig. 1 Structure bearing some resemblance to a corpus luteum. Removed from broad ligament in Lia during exploratory operation of December 15, 1941. × 39.

Fig. 2 Graafian follicle and other ovarian tissue (at right) removed from anterior surface of uterus from Lia during exploratory operation of March 7, 1943. × 5.

Fig. 3 Section of right ovary from Lia showing region of operative defect (upper left). × 5.

tive explanation would be that during oöphorectomy a small fragment of ovary was dropped into the body cavity and became incorporated secondarily in this region.

The nature of the tissue removed from the right broad ligament during the first operation following oöphorectomy is puzzling. The chief reason for thinking that it may be ovarian is that it bears some resemblance to a corpus luteum, being composed of a somewhat folded wall which surrounds a hemorrhagic mass (fig. 1). The structure is much smaller than the corpora lutea found in the other subjects and the distinct cell membranes characteristic of luteinized elements are not present. We hesitate to conclude, therefore, that this structure is ovarian, although it is equally clear that the possibility cannot be excluded.

The identity of the tissue found on the left side of the uterus at the time of the second exploratory operation is less equivocal. A sizable follicle composed of a well differentiated stratum granulosum and theca interna is present in the connective tissue adjacent the myometrium (fig. 2). Elsewhere in the follicle a highly disorganized cumulus oöphorus can be distinguished, but no ovum is present. Evidences of atresia are present everywhere and, as in the tissue removed at the time of the first operation following oöphorectomy, it is difficult to believe that it was functional. Nevertheless, we are confronted by the fact that cyclic genital activity including menstruation occurred prior to its removal and was not shown thereafter.

Continuous with the large follicle and extending as a thin strip through 1214 sections cut at 12 μ is a region of ovarian tissue containing two small follicles and numerous luteinized cells. The part of the tissue containing the latter bears many resemblances to the luteinized structure removed during the first exploratory operation.

Comparison of the cycles preceding oöphorectomy with those displayed later must be made with reservations because only three complete cycles were shown between the time of oöphorectomy and the second operation, December 15, 1941. Prolonged preswelling phases occurred. They are also seen in the histories of the other subjects and are thought of as being characteristic of the cycles shown under the conditions which prevailed in these animals. Significance cannot be attached to the somewhat longer swelling phases and the shorter postswelling phases. Had more cycles been displayed it might be that in Lia as in the other animals most of the swelling phases, postswelling phases and menstruations following oöphorectomy would not have been different from those displayed during the preoperative period.

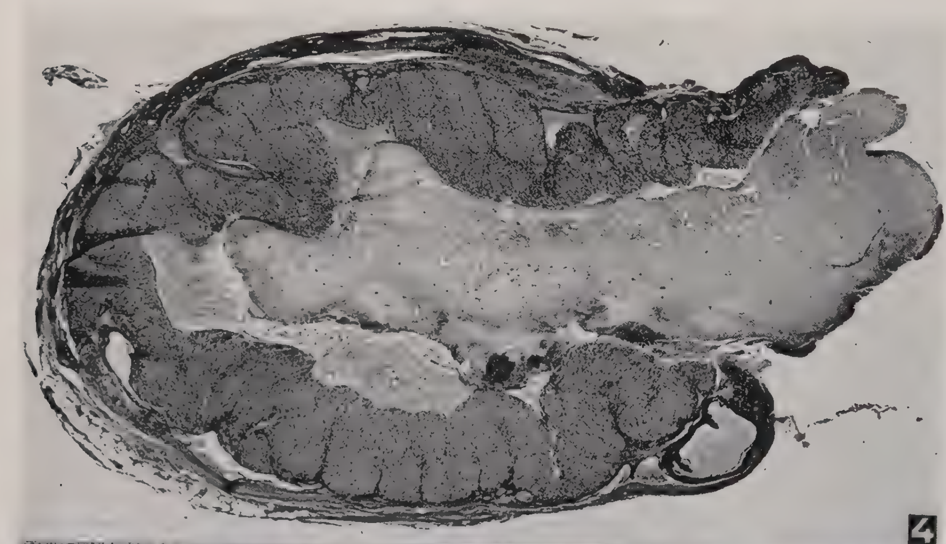
Protocol of May

DATES	PRESWELLING PHASE	SWELLING PHASE	POSTSWELLING PHASE	MENSTRUATION	CYCLE
9/ 7/40	0	16	13	2	31
10/ 8/40	2	15	14	2	32
11/ 9/40	3	19	3 +	.	incomplete
12/ 5/40	(Fourth day of postswelling phase). Hysterotomy with ligature of left tube.				
12/ 9/40–12/15/40	Postoperative bleeding				
12/10/40–12/16/40	Genital quiescence				
12/17/40	1	25	6	2	34
1/19/41	3	21	13	3	40
2/28/41	2	19	14	2	37
4/ 6/41	0	20	6 +	.	incomplete
5/ 2/41	(Seventh day of postswelling phase). Removal of second (left) ovary. Massive. adhesions throughout the pelvis involved the parietal peritoneum as well as all of the visceral peritoneum. The ovary was cystic and as large as a medium-sized orange.				
5/ 5/41–5/6/41	Postoperative bleeding				
5/ 7/41	88	11	16	2	117
9/ 1/41	4	6	15	2	27
9/28/41	13	18	7	2	40
11/ 7/41	0	14	13 +	.	incomplete
12/ 3/41	(Fourteenth day of postswelling phase). Exploratory laparotomy. Extensive adhesions prevented a completely satisfactory pelvic exploration, but a nodule composed of ovarian tissue was removed from the broad ligament on the left side (figs. 4 and 5).				
12/ 6/41–12/12/41	Postoperative bleeding				
12/13/41	10	17	5	3	35
1/17/42	17	9	11 +	.	incomplete
2/22/42	(Twelfth day of postswelling phase). Hysterectomy. A small nodule attached to the anterior surface of the uterus near the left utero-tubal junction was also removed, but when examined microscopically no ovarian tissue was found.				

The condition of the enlarged left ovary precluded the possibility of determining whether its removal was complete. On the other hand, the assumption that the ovarian tissue found in the nodule removed during the first exploratory laparotomy developed from a fragment left behind when the second ovary was removed seems justified from what was found in the other subjects.

The ovarian tissue differs from that removed from Lia in that well defined luteal and follicular structures are present (figs. 4 and 5). The corpus luteum (fig. 4) is strongly hemorrhagic, but is thought to have been functional because the postswelling phase had already reached a length that is associated with the presence of an active corpus luteum (Young and Yerkes, '43). The larger follicle (fig. 5) is atretic and no ovum is present, unless the granular mass in the cavity of the cumulus oöphorus is the remains of an ovum. A few mitotic divisions can be seen in the smaller follicle shown in figure 4, but the ovum presents evidence of degeneration as judged by the faded appearance of the zona pellucida and it is difficult to believe that continued growth and ovulation would have occurred.

Failure to find ovarian tissue in the nodule removed during the second operation following the removal of the secondary ovary does not exclude the possibility that it was present. There has been no



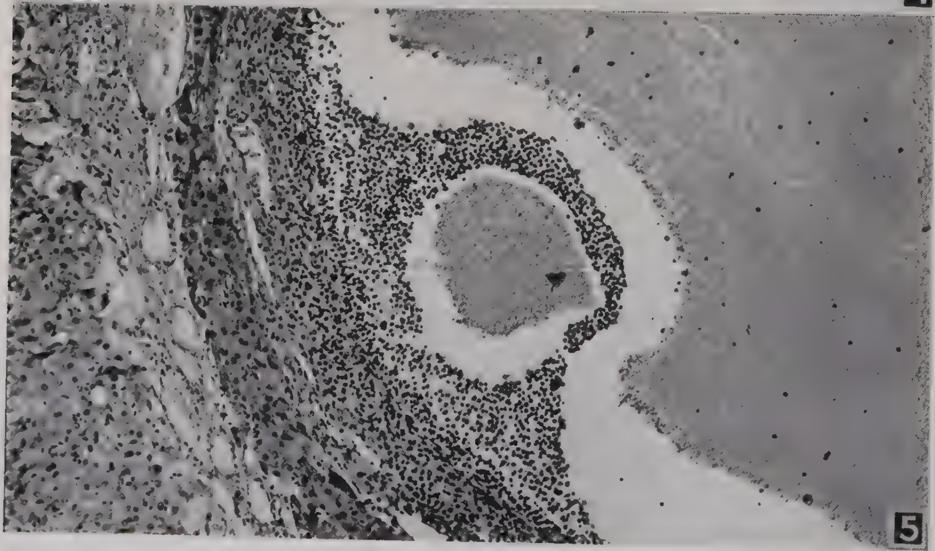


Fig. 4 Corpus luteum and graafian follicle removed from broad ligament in May during exploratory operation of December 3, 1941. × 11.

Fig. 5 Cumulus oöphorus in atretic follicle found in May during exploratory operation of December 3, 1941. × 90.

opportunity to examine all of the uterus microscopically and the permanent suppression of cycles which followed hysterectomy suggests that active tissues were removed at this time.

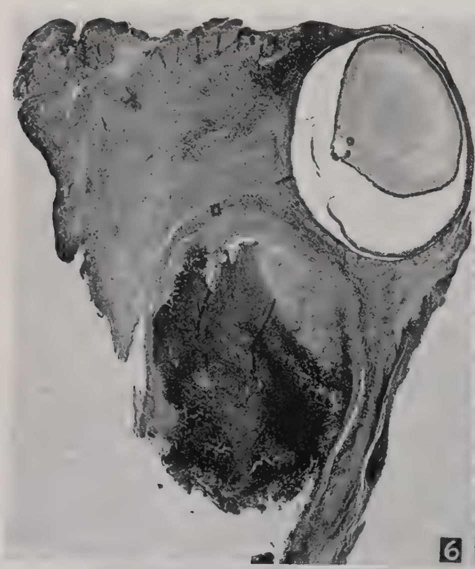
As in Lia, irregularity was shown in the length of the cycle. All phases except menstruation were affected, but the greatest irregularities involved the preswelling phase.

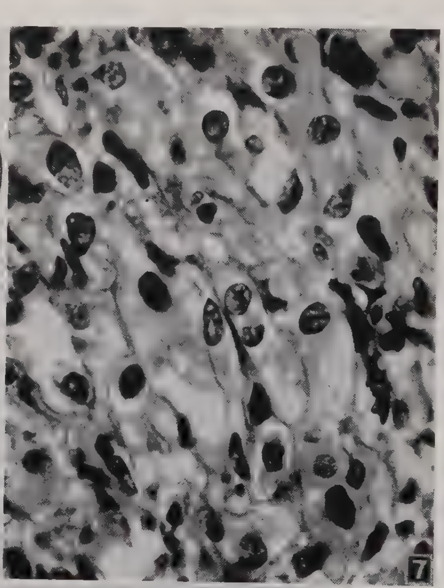
Protocol of Mimi

DATES	PRESWELLING PHASE	SWELLING PHASE	POSTSWELLING PHASE	MENSTRUATION	CYCLE
12/ 3/40	3	18	9	8	38
1/10/41	5	11	11	4	31
2/10/41	11	16	10	5	42
3/24/41	1	19	10	4	34
4/27/41	2	8 +	..	.	incomplete
5/ 6/41	(Ninth day of swelling phase). Removal of second (right) ovary.				
5/ 7/41–5/14/41	Postoperative bleeding				
5/15/41	1	12	10	5	28
6/12/41	10	15	6	4	35
7/17/41	26	8	15	4	53
9/ 8/41	8	12	11	3	34
10/12/41	34	12	10	6	62
12/15/41	(Third day of preswelling phase). Exploratory laparotomy. A small nodular mass of tissue was found between the layers of the broad ligament on the left side near the ovarian pedicle. It contained a hemorrhagic mass surrounded by a wall of luteinized tissue and a single large follicle (figs. 6 and 7), 4 much smaller follicles in which antra had developed, and 5 follicles without antra.				
12/17/41–12/19/41	Postoperative bleeding				
12/20/41	12	14	11	5	42
1/31/42	22	11	3 +	.	incomplete
3/ 7/42	(Fourth day of postswelling phase). Exploratory laparotomy. Removal of cystic structure from broad ligament on right side containing a hemorrhagic corpus luteum (fig. 8) and a single small follicle.				

Removal of the right ovary was complete, but about 10% of the left ovary was left behind. The fragment was larger than in Lia and this circumstance may account for the more extensive follicular development in Mimi. The hemorrhagic structure (figs. 6 and 7) is not as well defined as the corpus luteum removed during the second exploratory operation or as that removed from May (fig. 4), but is thought to have been functional because the length of the postswelling phase of the preceding cycle was normal. In neither mass of tissue removed during the exploratory operations was more than one corpus luteum found although more than one cycle had been displayed and remains of several corpora lutea are seen in the ovaries from normal adult females.

The greatest irregularity in the cycles following the removal of the second ovary was in the preswelling phase. Most were longer than the average, a fact which in this subject as in the others, is thought to be accounted for by follicular quiescence, or, if growth of any small follicles was occurring, by the absence of a stimulus sufficient to initiate tumescence.





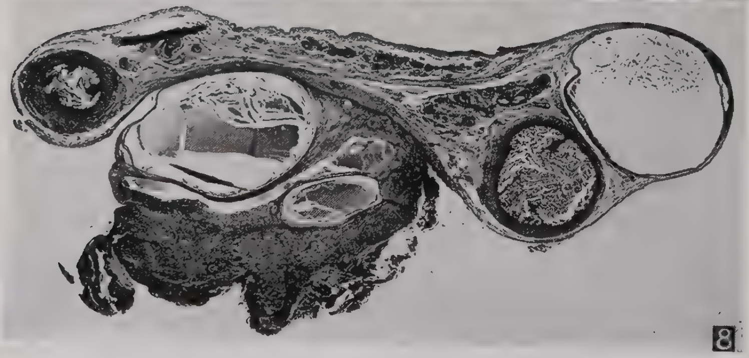


Fig. 6 Largest grafian follicle and hemorrhagic corpus luteum removed from Mimi during exploratory operation of December 15, 1941. × 5.

Fig. 7 Area enclosed in square in figure 6 showing granulosa lutein cells. × 600.

Fig. 8 Ovarian tissue and sections of mesosalpinx removed from Nira during exploratory operatiion on November 24, 1941. × 3. The ovarian tissue developed from the fragment left behind when the ovary shown in figure 9 was removed.

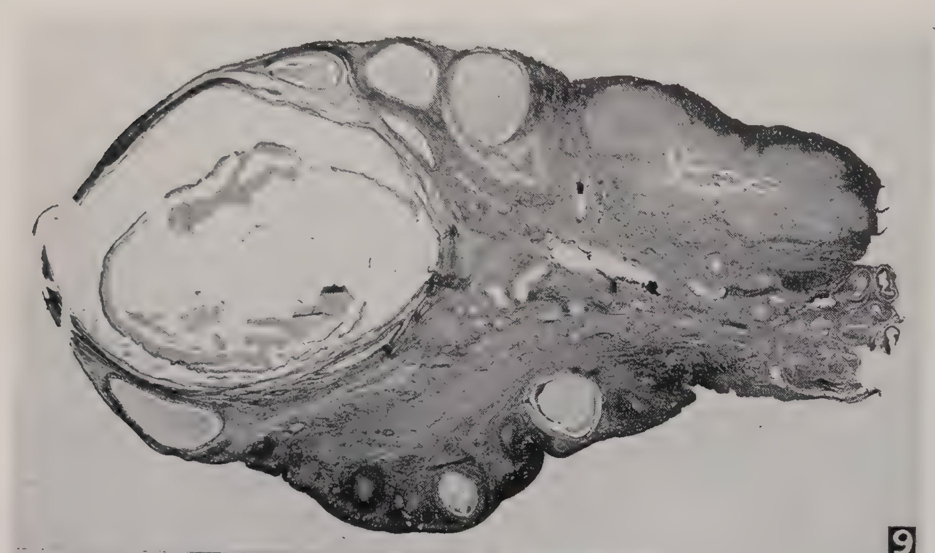
Protocol of Nira

DATES	PRESWELLING PHASE	SWELLING PHASE	POSTSWELLING PHASE	MENSTRUATION	CYCLE
11/ 4/40	0	15	13	2	30
12/ 4/40	3	16	12	4	35
1/ 8/41	5	16	10	6	37
2/14/41	4	17	12	2	35
3/21/41	4	11 +	..	.	incomplete
4/ 4/41	(Twelfth day of swelling phase). Bilateral oöphorectomy				
4/11/41–4/17/41	Postoperative bleeding				
4/18/41	2	8	14	2	26
5/14/41	38	14	13	1	66
7/19/41	19	13	13	3	48
8/10/41–9/2/41	(Fourth day of swelling phase through first day of menstruation). Collection of 24-hour specimens of urine on alternate days for assay of excreted estrogenic substances.				
9/ 5/41	3	13	12	2	30
10/ 5/41	6	16	13	2	37
11/11/41	9	5 +	..	.	incomplete
11/24/41	(Sixth day of swelling phase). Exploratory laparotomy. In the region of the proximal third of the mesosalpinx on the left side a mass of ovarian tissue nearly an inch in diameter was found (fig. 8).				
11/28/41–11/30/41	Postoperative bleeding				
12/ 1/41	45	7 +	..	.	incomplete
1/22/42	(Eighth day of swelling phase). Exploratory laparotomy and hysterectomy. Following separation of adhesions involving the bladder, omentum and uterus, a small nodule located in the broad ligament near the utero-tubal junction on the right side was palpated. It ruptured immediately and was assumed to have been either a developing follicle or follicular cyst. Removal of the portion of the broad ligament containing the ruptured cyst was supposedly accomplished, but microscopic examination of the mass did not reveal any ovarian tissue.				
1/23/42–1/27/42	Detumescence				

In Nira removal of the ovaries was incomplete. Small fragments were left behind near the hilus (fig. 9). The defects extend through 170 slides out of the 295 in the series made from the left ovary and 35 slides out of the 183 in the series made from the right ovary. It is estimated that less than 5% of the total ovarian mass remained. The follicles which must have developed from cells in one of the remnants appear better developed and larger (fig. 8) than those found in the tissue removed from Lia, May and Mimi. As in May and Mimi the corpus luteum is strongly hemorrhagic; nevertheless, it was associated with a postswelling phase of normal length and is assumed to have been functional.

An asymetrical distribution of ovarian cortical tissue on the stalk of each ovary (fig. 9) is similar to that seen even more clearly on an ovary removed from another subject, Lita (fig. 10). Such a condition, especially if it is a peculiarity of the chimpanzee, could easily have led to the operative failure with which we were confronted.

Because of the existence of a record of the amount of excreted estrogenic substances during a cycle prior to oöphorectomy (Fish, Young and Dorfman, '41), Nira was selected for a similar study during one of the cycles following the removal of the main mass of ovarian tissue. Except for the 24-hour period at the beginning of menstruation, the amount of excreted estrogenic substances was less than that excreted during a single cycle approximately 14 months



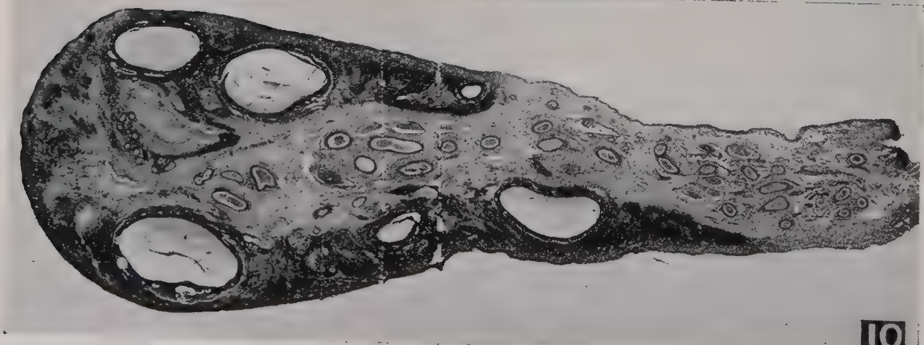


Fig. 9 Section of left ovary from Nira showing region of operative defect (upper right) and asymmetrical distribution of cortical stroma on stalk. × 6.

Fig. 10 Section through left ovary from Lita showing asymetrical distribution of cortical tissue on stalk. × 7.

previously and therefore prior to oöphorectomy (table 1). There has been no opportunity to determine the extent of variation from cycle to cycle, consequently it is not known if the amount excreted by an unoperated adult female ever is as small as that excreted by Nira during this cycle following oöphorectomy. The peaks shown during the 24-hour period on the seventh and eighth days and during the 24-hour period on the last day of the postswelling phase and the first day of menstruation are suggestive of those seen in the cycle of unoperated animals.

TABLE 1

Amount of estrogenic substances excreted by Nira prior to and after incomplete oöphorectomy.

AMOUNT PER 24 HOURS DURING A SINGLE CYCLE FOLLOWING INCOMPLETE OÖPHORECTOMY			AMOUNT PER 24 HOURS DURING A SINGLE CYCLE PRIOR TO OPERATION (FISH, YOUNG AND DORFMAN, '41)
Dates	Time of cycle	I.U.	Range during corresponding parts of cycle
	Swelling phase		
Aug. 10/11	4th, 5th days[1]	40	40 to 290 I.U. per 24 hours
Aug. 13/14	7th, 8th days	110	
Aug. 17/18	11th, 12th days	40	
	Postswelling phase		
Aug. 20/21	1st, 2nd days	< 20	105 to 385 I.U. per 24 hours
Aug. 25/26	6th, 7th days	15	
Aug. 28/29	9th, 10th days	< 15	
Sept. 1/2	13th day, postswelling phase and 1st day, menstruation	60	40 I.U.

[1] Collection period, 9 A. M. the first day to 9 A. M. the following day.

As in May, ovarian tissue was not found in the nodules removed during the second exploratory operation. Microscopic examination of the uterus has not been possible and loci of generative activity less conspicuous than that found along the uterine wall in Lia may be present.

No protocol was prepared for the fifth subject, Kambi. Less than 5% of the right ovary was left behind and, although the fragment appears to have been larger than that in Lia, cyclic genital activity was not resumed.

DISCUSSION

When the ovaries were being removed from the four chimpanzees in which genital cycles were resumed after the operation, it was thought that oöphorectomy had been complete. Not until the ovaries were studied microscopically did it become apparent that small portions had been left behind. The accident may be accounted for by the asymmetrical distribution of cortical ovarian stroma on the stalk. Whatever the explanation is, the experience has yielded information which might not otherwise have been obtained.

There is now every reason for believing that in the chimpanzee, as in the rat, mouse, guinea pig and rabbit, very small picees of ovarian tissue are sufficient to insure a continuation of cyclic genital activity, at least for 10 months. Indications are, from the location of the nodules in the broad ligament in Mimi and Nira, that the development of the tissue responsible for this activity took place in situ from cells left behind at the time of oöphorectomy; nothing suggests that an unintentional transplantation of ovarian cells occurred. In the case of Lia, on the other hand, adhesions did not seem sufficiently extensive to account for the presence of the ovarian tissue found in the connective tissue surrounding the myometrium near the utero-tubal junction. Development of ovarian tissue in this location could better be accounted for by the accidental transplantation of cells from the ovary, despite the fact that there is at least one report of ovarian tissue in this location which was not connected with the ovaries (Thaler, '21, quoted from Menge and von Oettingen, '30).

The character of the cycles displayed following removal of the main mass of the ovaries was essentially the same in each of the four animals. Irregularities that are within the normal range of variation were shown in the swelling phase, the postswelling phase and menstruation, but on the whole these parts of the cycle were less affected than the preswelling phase. In all the subjects the preswelling phase tended to be longer after ovariectomy, indicating, we believe, that the follicles were not at first large enough to initiate genital swelling, but once a certain size was attained, functional activity as measured by the beginning of tumescence began.

Some evidence suggests that other primates including man are not unlike the chimpanzee with respect to the ease with which ovarian tissue develops from exceedingly small fragments and with respect to the extent to which small pieces of ovarian tissue are sufficient to insure a continuation of cyclic genital activity, at least for a while after the main mass of ovarian tissue has been removed. Two cases of ectopically located ovarian tissue have recently been encountered in Rhesus monkeys. In one animal the ovarian tissue had been greatly reduced during a series of operations, but regeneration was noted as well as the occurrence of a small piece in the broad ligament of monkey 90 (Van Wagenen and Morse, '42).

The second case involved a monkey in which one ovary was removed on the twenty-fifth day of pregnancy, the other having been removed 2 years before. After parturition the red coloration of the sexual skin persisted and the monkey ran very regular cycles several months. The question of the source of the hormone responsible for this condition was raised by Hartman ('41). Some time later, after the uterus had been removed, a corpus luteum was found in the connective tissue surrounding the myometrium (Corner, personal communication). Although the ovaries were not available for examination, Corner and Hartman have concluded that a small fragment separated at the time of the first oöphorectomy must have become incorporated in the connective tissue in this region.

A case in the Hamadryas baboon reported by Blotevogel ('32) is different in that the development of ectopic ovarian tissue from a rest of cells rather than the regeneration of a fragment is suggested, but as in the chimpanzee and Rhesus monkey, the ability of small amounts of ovarian tissue to develop and carry on functional activity is demonstrated. Blotevogel ovariectomized three baboons in August, September, and October, 1929. Cyclic activity stopped until the end of November, 1930 when renewed estrous activity was shown by the animal ovariectomized in September, 1929. The first heat occurred December 4, 1930 and the next period of activity began 5 months later. Completeness of the operations was verified by a microscopic examination of the ovaries. An exploratory laparotomy, July 4, 1931, revealed a nodule about the size of the end of the little finger in the angle between the tube and uterus on the left side. It was covered with peritoneum, connected to the uterine wall by means of a thin stalk and had no connection with the site of the ovaries. The nodule along with the connective tissue of the broad ligament was removed for study. The connective tissue contained no ovarian tissue, but what he regarded as a true ovary was found in the nodule. It contained a corpus luteum and eighteen follicles around the edge. The stalk bore a close resemblance to the ligamentum ovarii proprium. The irregularity of the cycle during the winter of 1930–31 was attributed to the small number of follicles present in the nodule, but it is the opinion of the writer that it could as well have been a seasonal anestrum such as his animals displayed prior to the operations and such as in shown by some chimpanzees (Young and Yerkes, '43).

In the human female the functional capacity of small fragments of ovaries has long been recognized. More interesting, therefore, than any data bearing on this point is a comparison of the postoperative histories of our four chimpanzees with those of the human females in which there was a resumption of cyclic activity following what were believed to be complete bilateral oöphorectomies. The clinical literature contains not less than eighteen such cases (Robertson, 1890; Gordon, 1896; Sutton, 1896; Burckhard, '00, two cases; Morris, '01; Baldwin, '02; Doran, '02; Meredith, '04; Wilcox, '06; Lucas-Championnière, '07; McArthur, '24, five cases; Deutschman, '30; Scott, '36).

Evaluation of these reports is obviously difficult; removal of the ovaries would seem to have been complete, especially in the nine cases in which oöphorectomy was accompanied by salpingectomy (Baldwin, Deutschman, Gordon, Lucas-Championnière, McArthur, Morris and Wilcox) or by removal of half the tubes (Scott). It is suggestive, however, that in certain respects the postoperative histories were similar to those shown by the chimpanzee. The interval between oöphorectomy and the resumption of cyclic genital activity as reported for sixteen of the eighteen human females was strikingly like that seen in the four chimpanzees. No cessation or an almost immediate resumption of menstruation was reported by Baldwin, Burckhard, Doran, Lucas-Championnière and McArthur (one patient). Morris stated that his patient began to menstruate soon after the operation. McArthur noted that in three patients menstruation was reestablished weeks afterwards. Wilcox' patient began to menstruate about a month after she was discharged from the hospital. The interval was 2 to 3 months in the case described by Gordon, 4 months in that described by Robertson, 5 months in Scott's patient, 10 months in Meredith's patient and less than 2 years in the case reported by Deutschman.

Regularity of menstruation following its resumption is reported by Deutschman, Doran, Gordon, McArthur (four cases), Meredith, Morris and Wilcox. No instance of any striking irregularity is given. If allowance is made for the possibility of even slight inaccuracies in the reports of the patients, the similarity to the histories shown by the chimpanzees will be apparent.

The observations which cannot be dismissed by the assumption that a fragment of an ovary was left behind are those by Thaler ('21) and Blotevogel ('32). In the case described by Thaler the ectopic ovarian tissue was discovered before the ovaries were removed. In the baboon studied by Blotevogel the completeness of oöphorectomy was confirmed by a microscopic examination of serial sections of the ovaries. Unless there was an error of observation, the existence of these cases compels us to admit the possibility that small rests of ectopic cells having the ability to form ovarian tissue accounted for the results obtained by the clinicians. On the other hand, the likelihood is that such an anomaly is very rare. From the evidence we have been able to gather it seems more probable that some defect in the operation accounted for the resumption of cyclic genital activity reported as occurring following bilateral oöphorectomy in the human female.

SUMMARY AND CONCLUSIONS

In four of five adult female chimpanzees in which removal of the ovaries was incomplete, cyclic genital swelling and menstruation were resumed after intervals from 9 to 92 days and continued for as long as 10 months. At this time the ovarian tissue responsible for the cyclic activity was removed. The most pronounced effect was a prolongation of the preswelling phase in some cycles. Any effect on the length of the other parts of the cycle was slight. Assays of urine specimens from one subject suggested that the amount of excreted estrogenic substances is much less in such animals than in intact subjects displaying cyclic activity.

Microscopic examination of the excised ovaries from three of the four subjects disclosed that small fragments, estimated to be not more than 0.5% to 5% of the total ovarian mass, had been left behind. It is clear therefore that in one of the two primates most closely related to man graafian follicles and corpora lutea of sufficient size to initiate and maintain cyclic genital activity for 10 months can quickly develop from exceedingly small fragments of ovarian tissue. The failure to complete oöphorectomy by an operative technique which was the same as that employed in the human female may have been due to an asymmetrical distribution of cortical ovarian stroma on the ovarian stalk.

A comparison of the postoperative histories of eighteen human subjects in which cyclic genital activity is reported following bilateral oöphorectomy with the four chimpanzees suggests that an incomplete removal of the ovaries rather than the development of accessory ovarian tissue from an ectopic rest was involved.

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THE PALMARIS LONGUS MUSCLE AND TENDON. A STUDY OF 1600 EXTREMITIES[1]

ARTHUR F. REIMANN, EDWARD H. DASELER, BARRY J. ANSON AND LINDSAY E. BEATON

Department of Anatomy, Northwestern University Medical School, Chicago, Illinois

THREE FIGURES

The palmaris longus is one of the most variable muscles in the human body. It is considered to belong in the class of retrogressive muscles (Bryce, '23). With the palmar aponeurosis the muscle represents the most superficial part of the primitive common flexor muscle of the fingers.

Among vertebrates the palmaris is restricted to the mammals, where, in the succession of mammalian orders, no regularity or progression of its presence or absence exists. At one end of the mammalian series, the muscle is absent as frequently in the species of Edentates as it is present (Windle and Parsons, 1899). The palmaris longus is regularly found in ruminants, pachyderms, rodents and carnivores, but is wanting in cetaceans, insectivores and cheiroptera. Although best developed in the former group of tetrapodes, it is still subject to a number of variations, the most notable being fusion with the subjacent flexor digitorum sublimis. In general, the muscle is best developed where the forelimb functions for weight-bearing and progression in a role similar to that of the gastrocnemius of the lower extremity.

Among primates, the palmaris longus muscle is found in the lower groups, but in the higher apes it is again variably absent. Appearing well-developed and regularly present in the orangutan, the muscle is occasionally absent in the gibbon and chimpanzee (Kohlebrugge, 1897; Keith, 1899), and frequently absent in the gorilla. Humphrey (1872) and LeDouble (1897) both consider this retrogression to be evidence of the gradual development of prehension, i.e., diversion of muscular power for the independent motion of parts of the manus. As if in response to such need, the flexor digitorum sublimis and flexor digitorum profoundus are large at the expense of the palmaris longus and of the flexor carpi ulnaris. Considered collectively, any of the above mammalian groups, in which the palmaris longus muscle is well developed, possesses small or regressive superficial flexors of the digits. In those groups in which the flexor digitorum sublimis is in the ascendant, the palmaris longus muscle is likely to be regressive and susceptible to a number of variations. All of these variations of shape, position or attachment, have their distinct counterpart in the human forearm, so that most of the variations recorded hereinafter for man are comparable with the muscle or its variations recorded for other mammals.

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[1] Contribution no. 414 from the Anatomical Laboratory of Northwestern University Medical School.

Typically, the palmaris longus of men is a slender, fusiform muscle situated between the flexor carpi radialis and flexor carpi ulnaris, and overlying the flexor digitorum sublimis. Its chief area of origin is the medial epicondyle of the humerus. It inserts by means of a slender flattened tendon which expands distally into the apex of the triangular palmar aponeurosis and into the transverse carpal ligament. Departures from this regular type are fairly common; they will be described and figured hereinafter.

MATERIALS AND METHODS

The current study covers a 10-year period during which 1600 extremities were examined;[2] of these 398 were recorded with no reference to body side or cadaver; 478 arms were recorded as right or left, but not by cadaver; 724 were recorded for both body-half and cadaver. Major variations of the palmaris were noted together with the incidence of its aberrant forms in 530 extremities. The specimens were adult male and female American whites and negroes (in approximate ratios of 10:1 and 7:1, respectively).

OBSERVATIONS AND DISCUSSION

Variations in the palmaris longus may be classified as follows: complete agenesis; variation in the location and form of the fleshy portion; aberrancy in attachment at either extremity; duplication or triplication; accessory slips; replacing elements of similar form or position.

1. *Absence*

The palmaris longus, like the pyramidalis, psoas minor, and plantaris muscles is rather frequently absent.[3] The incidence of agenesis in the present study is 12.8% (205 in 1600 arms). Gruber (1868, 1872) reports the incidence of absence of the muscle as 12.7% (178 in 1400 studied); Schwalbe and Pfitzner (1899), 20.4% (106 in 520); LeDouble (1897), 17.5% (91 in 520). The percentage absence in these lots combined is 14.3 (580 in 4040). Adachi (1909) reports among the Japanese an absence of the palmaris longus in 3.4% of arms (30 in 884), while Nakano ('23) reports an incidence of agenesis in the Chinese of 2.2% (2 in 95). Thus it is evident that agenesis is much more common in the Occidental than in the Oriental races.

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[2] The authors gratefully acknowledge the generosity of Prof. O. F. Kampmeier, Prof. T. T. Job, and Dean J. J. Sheinen who made available material in their laboratories at the Medical School of the University of Illinois, Loyola Medical School, and the Chicago Medical School, respectively.

[3] The incidence of agenesis of the pyramidalis has been reported as 17.7% (Beaton and Anson, '39), and 17.4% (Ashley-Montagu, '39).

Analysis by sides of the same cadaver shows that bilateral symmetry is preponderant over asymmetry. The present authors encountered 30 instances of bilateral absence in 362 bodies (8.3%); absence on the right side only in 17 bodies (4.7%) and on the left side only in 13 bodies (3.6%). Gruber encountered 40 instances of bilateral absence in 400 bodies (10.0%); absence on the right side only in 4 bodies (1.0%) and in 16 bodies (4.0%) absence on the left side. LeDouble found 27 instances of bilateral absence in 260 bodies (10.4%); absence on the right only in 15 bodies (5.8%) and on the left in 22 bodies (8.4%). Total incidence of bilateral agenesis, then, is 97 instances in 1022 bodies (9.5%); 36 times (3.5%) on the right and 51 times (5.0%) on the left.

In regard to the incidence of palmaris agenesis in relation to body sides, the following results are presented. In the present series, in 1202 extremities so recorded, the palmaris was absent 76 times on the right as compared with 70 times on the left. In 1400 arms examined by Gruber, the palmaris was absent 78 times on the right and 100 times on the left side. Le Double, in 520 arms examined, noted absence on the right in 42 cases as compared with 49 cases on the left. When the above figures are totaled, it is found that of 3122 arms examined, agenesis occurred on the right side in 196 cases, on the left side in 219 cases. Absence, then, is slightly more frequent on the left than on the right side.

Schaeffer ('09) and later Thompson ('21), recording the presence and absence of the palmaris in living subjects (by inspection of flexor tendons at the wrist) found similar frequencies of agenesis: 23.0% on the left (184 in 800 arms) and 16.3% on the right (403 in 2401 arms). Inaccuracies which are inherent in the method employed account for the higher percentages.

Records of sex and racial differences indicate that the incidence of agenesis is considerably lower in negroes than in whites, and lower in males (of each race) than in females (Thompson and others).

Differences in the incidence of agenesis in the series hereinbefore recorded, the predominance of bilateral agenesis and the more significant differences between body sides and between sexes cannot be explained on the basis of chance (Thompson). This author, in a study of 102 families, presents evidence to indicate that the absence of the muscle is inherited as a Mendelian dominant factor that is possibly sex-linked and influenced by such modifying factors as related structures, body side and sex.

2. *Variation in form*

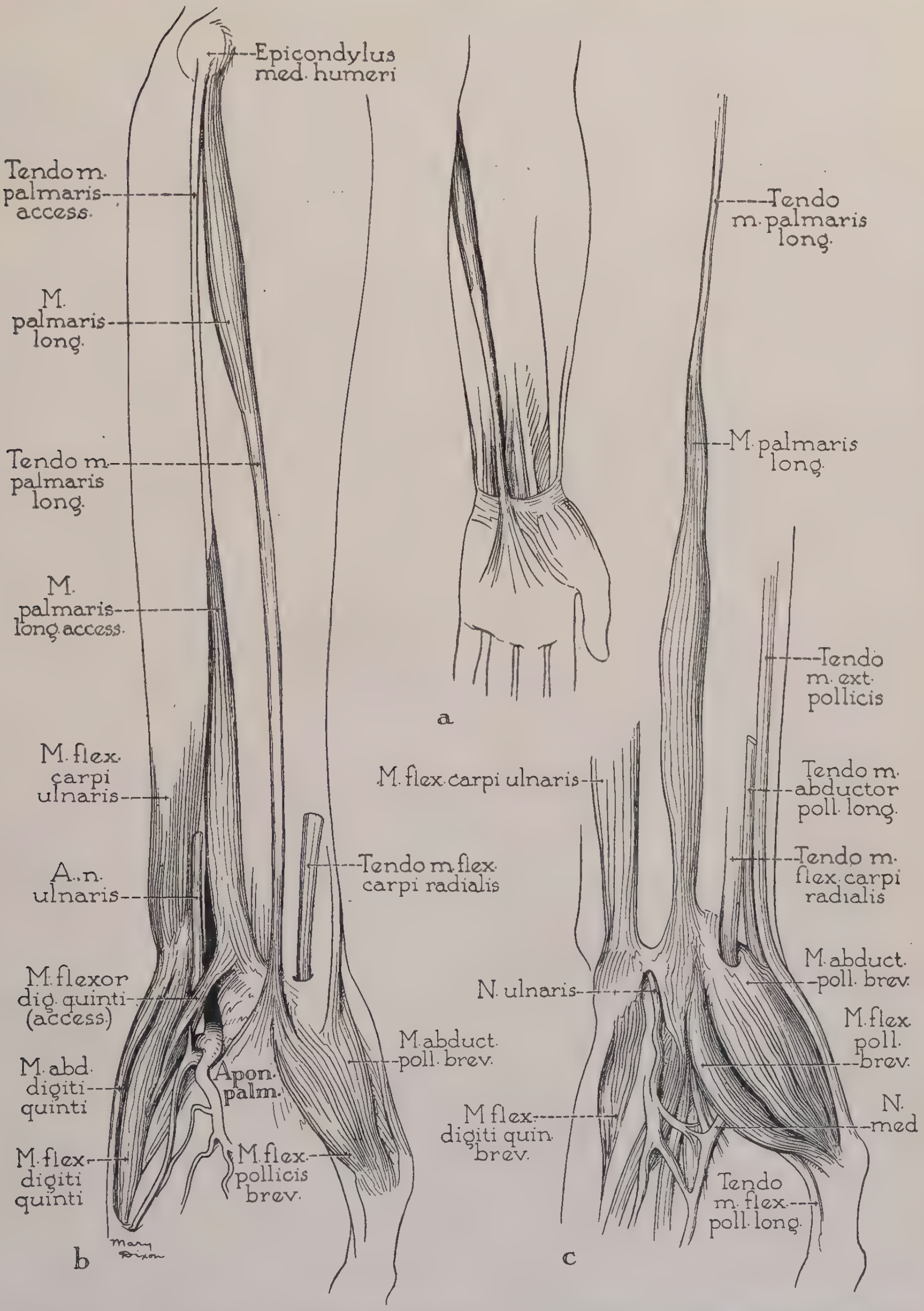
In the 530 arms examined for anomalies other than agenesis, the incidence of variations of all types is 9.0% (46 in 530 arms).

Variations in form are commonly seen. The belly of the muscle is normally proximal in position (fig. 1a). But it may be centrally placed (fig. 2a) or entirely distal (figs. 1b, 1c). In addition, a digastric type occurs, in which proximal and distal muscle bellies are connected by a central tendon (1 in 530 arms). All phases of muscular development are encountered from a type completely muscular from origin to insertion, to a form in which only a fibrous vestige remained. Either the muscle belly or its tendon may be bifid, or both parts may be split. When a cleft is present in the muscle, the tendons therefrom are likely to insert separately into the palmar aponeurosis (fig. 2b). These several variations in form constitute 50% of all anomalies observed (exclusive of agenesis).

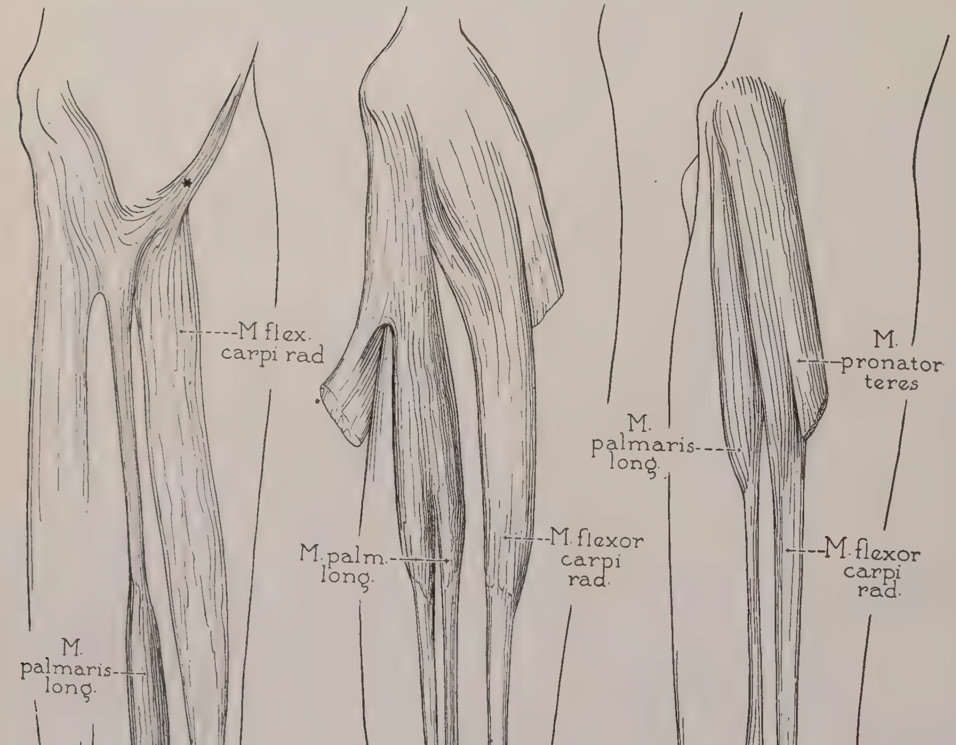
3. *Variation in attachment*

Variations in the origin and in the insertion of the palmaris longus occur with fair frequency. Normally the muscle arises from the common flexor tendon attached to the medial epicondyle of the humerus, and descends to a palmar insertion (fig. 1a). When auxiliary attachments are present they come from the antibrachial fascia and the related intermuscular septa. Accessory or isolated origin may be derived from the lacertus fibrosus (fig. 2a), flexor carpi radialis, flexor carpi ulnaris or flexor digitorum sublimis (Macalister, 1867).

The insertion of the palmaris is highly variable. In place of its usual insertion, the tendon may loose itself, at mid-forearm level, in the antibrachial fascia (fig. 2c); it may become partially or totally attached to the fascia of the thenar eminence (figs. 2b, 2c), or may blend with the expansion of the flexor carpi ulnaris insertion over the wrist and thus come to lie on either side of the median nerve. In addi-


Epicondylus med. humeri
Tendo m. palmaris access.
M. palmaris long.
Tendo m. palmaris long.
M. palmaris long. access.
M. flex. carpi ulnaris
A. n. ulnaris
M. flexor dig. quinti (access.)
M. abd. digiti quinti
M. flex. digiti quinti
Apon. palm.
M. flex. pollicis brev.
Tendo m. flex. carpi radialis
M. abduct. poll. brev.
Mary Dixon
b
a
Tendo m. palmaris long.
M. palmaris long.
Tendo m. ext. pollicis
M. flex. carpi ulnaris
Tendo m. abductor poll. long.
Tendo m. flex. carpi radialis
M. abduct. poll. brev.
N. ulnaris
M. flex. poll. brev.
N. med
M flex. digiti quin. brev.
Tendo m. flex. poll. long.
c

Figs. 1a to 1c, types of palmaris longus muscle. a, regular; b, duplication of muscle, the ulnar element possessing distal muscular part; c, palmaris with distally placed belly of broad insertion.


*
M flex. carpi rad
M. palmaris long.
M. flex. carpi uln.
a
M. palm. long.
M. flexor carpi rad.
b
M. pronator teres
M. palmaris long.
M. flexor carpi rad.
*
M. abduct. poll. brev.
c

Figs. 2a to 2c, types, continued. a, centrally placed muscle belly; proximally placed slip (*) joins lacterus fibrosis; b, bifid palmaris muscle, portions of equal size and with similar tendons; c, divided tendon, the ulnar slip (*) inserting into antibrachial fascia.

tion, the authors have observed a few specimens in which the tendon inserts into one or the other of the carpal bones forming the walls of the carpal canal. Instances of insertion into the tendons of the flexor digitorum sublimis, flexor digitorum profundus and flexor carpi radialis have been reported by LeDouble, but have not been encountered in the present study. The tendon may be bifid distally (figs. 2b, 2c), the extra slip inserting into any one of the above-named structures as reported by Macalister. The latter writer also noted an unusual palmaris muscle which, after attaching to the ulna at mid-forearm level, continued as a tendon into the transverse carpal ligament. An instance of insertion into the interosseus membrane was reported by Koster (1856).

Although variations in attachment are, as just described, of strikingly different types, their combined incidence is low, being 6.5% (3 in 46). Origin from the flexor digitorum sublimis and insertion into the hamate bone are the commonest variations within the general category.

4. *Duplication, etc.*

Duplication of the palmaris longus is of relatively common occurrence, being 4 cases in the 46 instances of variations encountered exclusive of agenesis.[4] The occurrence of duplication, in the present authors' series, is 0.8% (4 in 530 arms); this is much lower than Gruber's 3.1% (31 in 1000 arms).

When duplication does occur, the muscle on the radial side of the forearm is usually in its normal situation. The accessory, or ulnar, element (muscle and tendon) is likely to be smaller than the radial component. Frequently the ulnar member of the pair possesses a distal (fig. 1b), or intermediate muscle belly (Wood, 1866).

5. *Accessory slips and substitute structures*

In addition to instances of duplication, where each portion of the palmaris longus has the usual proximal and distal attachments, the single or double muscle may be augmented by accessory slips, with an incidence of 32.6% (15 in 46). The most common type in this group (4 of 15) is a small accessory muscle which arises from the palmaris tendon and inserts into abductor digiti quinti muscle belly (Macalister,

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[4] Gruber reported one case in which three palmaris longus muscles and tendons were present. The radial portion was normal, while the intermediate and ulnar divisions were rudimentary. They all arose from the medial epicondyle of the humerus; the palmaris proper inserted into the aponeurosis and into the carpal ligament, while the distal extremeties of the two smaller tendons united to form a common tendon with the palmaris longus proper over the wrist.

LeDouble).[5] A similar slip, with insertion into the flexor digiti quinti, occurred once in the present series (fig. 1b). Portions of the regular tendon may split off to insert broadly into the volar antebrachial fascia (fig. 2c). Macalister and Morrison ('16) describe a muscle, accessory to the abductor digiti quinti, whose fleshy portion lying in the distal forearm, arose by two heads, one from antebrachial fascia, the other through a tendon from the palmaris.

Accessory muscles may have widely divergent origins and yet eventually come to insert into the palmar aponeurosis or neighboring carpal ligament. In one specimen the auxiliary slip arose from the flexor digitorum sublimis by a tendon fused to the undersurface of that muscle (fig. 3c). The muscle belly appeared distally between the flexor carpi radialis and palmaris longus, where it obscured the median nerve, finally inserted broadly into the transverse carpal ligament. An accessory slip arising from the ulnar tuberosity and coronoid process has been reported (Macalister, Wood). In the current set of specimens an unusual accessory slip was observed, which, beginning as a thin tendon from the coronoid process, the radial tuberosity and the oblique line of the radius, ended as a short muscle belly at the proximal edge of the transverse carpal ligament and on the sheath for the tendon of the flexor carpi radialis (fig. 3b). This muscle conforms in certain respects to one originally described and named the radio-carpus muscle by Fano (1851). It has been since found to insert more regularly into radial carpal bones and second and third metacarpal bones (Gruber, Wood, Macalister), thus becoming an accessory flexor carpi radialis. Accessory tendons may arise as such from the antebrachial fascia and insert into the transverse carpal ligament. A muscle arising from the lower two-thirds of the ulna under the flexor carpi ulnaris for insertion into the transverse carpal ligament has been noted by Macalister.

In the absence of the normal palmaris muscle, the palmar aponeurosis and the transverse carpal ligament may receive the tendons of substitute muscles. The presence of a slip from the flexor digitorum sublimis has been described by many authors. A specimen in the present series possessed, bilaterally, an unusual stout muscle that arose from the lateral edge of the radius in its middle third external to the flexor digitorum sublimis under the pronator teres (fig. 3a). Below, its rounded tendon passed under the transverse carpal ligament to the

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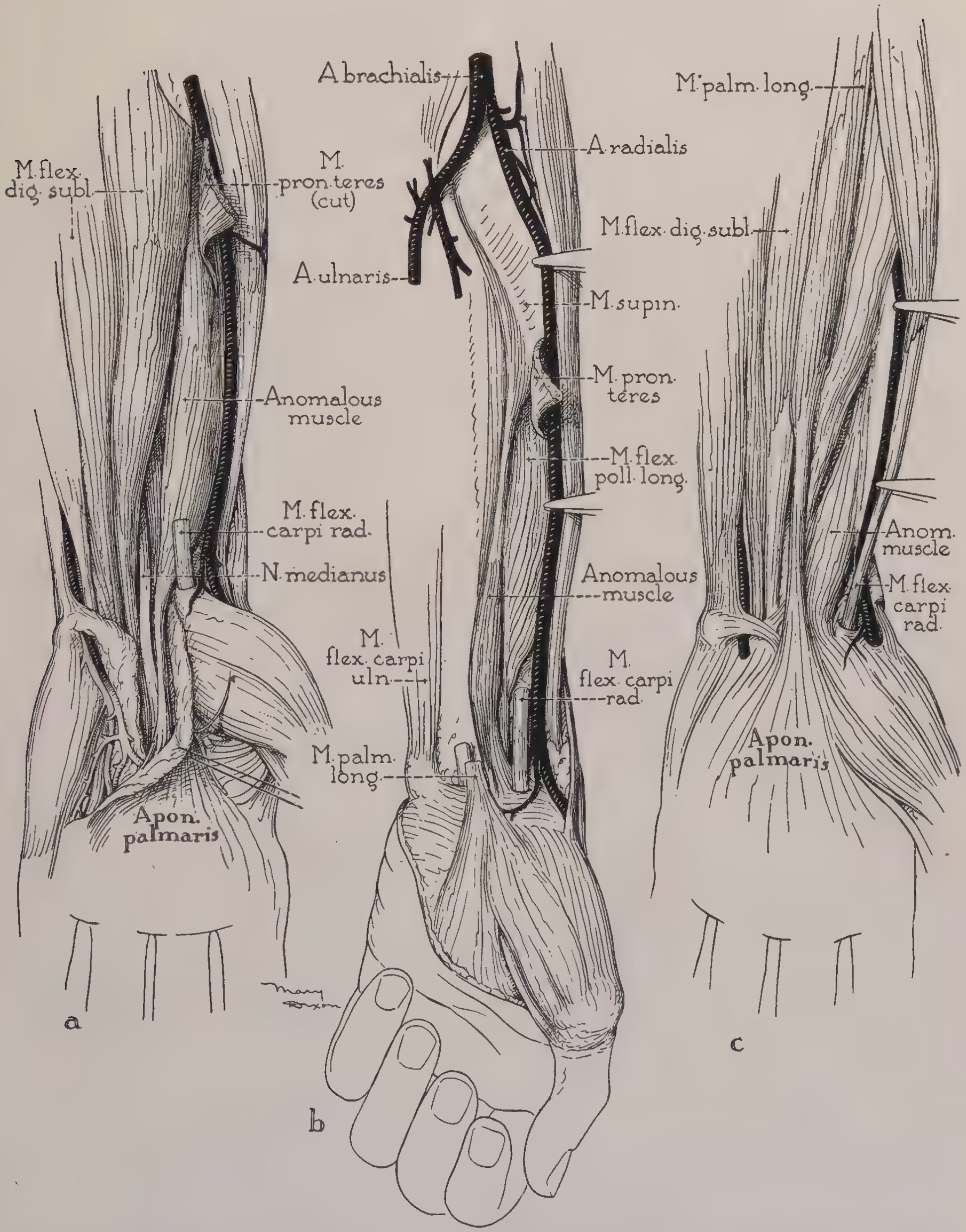
[5] The accessory adductor flexorum carpi radialem (Gantzen, MacWhinnie), passing from flexor carpi radialis tendon to abductor digiti quinti, is usually grouped among the variations of the palmaris. It is more accurately a variant and accessory of the former muscle.


M. flex. dig. subl.
M. pron. teres (cut)
Anomalous muscle
M. flex. carpi rad.
N. medianus
Apon. palmaris
a
A brachialis
A. radialis
A. ulnaris
M. flex. dig. subl.
M. supin.
M. pron. teres
M. flex. poll. long.
Anomalous muscle
M. flex. carpi uln.
M. flex. carpi rad.
M. palm. long.
b
M. palm. long.
Anom. muscle
M. flex. carpi rad.
Apon. palmaris
c

Figs. 3a to 3c, types, continued. a, short broad muscle replacing palmaris longus (tendon followed to deep aspect of aponeurosis); b, auxiliary muscle with long tendon of ulnar and radial origins (flexor digitorum longus, etc., removed); c, auxiliary muscle with robust, distally placed, fleshy part (flexor carpi radialis retracted).

radial side of the median nerve, broadened in the palm to insert into the deep aspect of the palmar aponeurosis. This muscle is the rare palmaris profundus of Frohse and Fraenkel ('08). In some respects it is similar to the radio-carpus muscle mentioned hereinbefore. A tendinous slip from the flexor carpi ulnaris (Macalister) and a muscular slip from the flexor carpi radialis (Wood), passing to the palmar aponeurosis, have also been regarded as substitute structures. The present authors have encountered a muscular slip and tendon which passed from the pronator teres to the palmar aponeurosis. Frohse and Fraenkel described an unusual bicipital muscle, one head of which arose from the ulnar tuberosity by a long thin tendon, the other having the attachments and form of their palmaris profundus.

In general it may be said that morphologic variations in the present study occur much more frequently on the right side (28 of 46) than on the left side (18 of 46).

CONCLUSIONS AND SUMMARY

In an anatomical study of 1600 arms the authors encountered 205 cases of agenesis (incidence, 12.9%). In 362 consecutive cadavers, bilateral absence was encountered much more frequently than absence only on the right or on the left, the ratio of absences being 30 : 17 : 13 (8.3; 4.7; 3.6% respectively). In 1202 extremities, the palmaris was absent 76 times on the right as compared to 70 times on the left.

The incidence of anomalies of all types, exclusive of agenesis, was 46 in 530 consecutive arms. Variations in position and form constitute one-half of these (23 in 46). A more varied group of accessory slips and substitute structures were encountered 15 times in the set of 46 anomalies, while duplication of the palmaris was encountered 4 times, aberrancies of attachment 3 times. Variation of the several types, combined, was more frequent on the right side (28 times) than on the left (18 times), in marked contrast to the relation of agenesis to body-side.

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OBSERVATIONS ON SUPERFETATION IN MICE

ROBERT A. LITTLEFORD AND HELENE M. GYSIN
Department of Zoology, University of Maryland, College Park

Weichert ('42) reporting on a case of parallel embryonic development in the rat, made certain observations pertinent to the problem of superfetation. He concluded that "contrary to the opinion of many investigators, it seems possible that a second pregnancy never occurs. Cases of "superfetation" may just as logically be explained on the basis of variation in time of implantation among the same set of fertilized eggs." This opinion contrasts sharply with that of Stowell ('41) who reported a probable case of superfetation in a mouse of the A strain and pointed out that "inability to produce indisputable proof of an observed superfetation should not altogether invalidate the observations."

The two opinions of Weichert and Stowell may be said to form a more or less accurate summary of present opinion in this matter. The main issue seems to be: does superfetation really occur, or is it merely a pseudo-phenomenon. Stowell further pointed out that superfetation is so rare a phenomenon that, consequently, observations have been made incidental to other experiments and "hence records and controlled conditions are not as good as one might desire." As the authors agree with Stowell in that a better understanding of the phenomenon will be facilitated by the accumulation of careful observations of its occurrence, the following observations on five probable cases of superfetation in mice are presented.

OBSERVATIONS

Since 1939, the authors have been engaged in an investigation of certain phases of longevity and aging in mice. During this time particular attention has been given to variations in frequency of litters, litter size, and weight cycle of the female and their relation to the general problem. The mice were mated in pairs and kept in granite-ware pans. Each morning the mice were weighed individually and, in the case of females, examined for the presence of the vaginal plug. Date of birth of each litter was noted, and the individuals making up the litter were weighed daily subsequent to birth. As a general rule, the female was not separated from the male, the members of the litter being removed from the parent nest at 21 days of age. In the course of the investigation, daily observations were made on 1023 pairs of mice divided among three inbred strains, observations on 304 pairs extending over the entire reproductive life of the female.

The period of gestation in non-suckling mice is usually 19 or 20 days (Snell, '41) and this period is usually prolonged by the presence of suckling young. Several cases have been observed during this investigation in which litters were born to the same mouse at shorter intervals. The five observed cases of superfetation are described individually below.

Case 1. Female no. 12–3, a black and tan individual, was mated on September 5, 1941 at 93 days of age. The first litter, ten in number, was born October 6, 1941. The second litter, also ten in number, was born 21 days later on October 27, 1941. Sixteen days later, November 12, 1941, another litter of eight individuals was born. This litter weighed 8.01 gm. at birth. The female reared both litters to maturity and the weight of the individuals of both litters at 21 days of age varied from 2.0 gm. more than the average weight to 1.7 gm. less than average weight for this particular stock at this time. It might also be of interest to mention that this particular female gave birth to another litter of ten individuals on December 12, 1941, all the members of which reached weaning age.

Case 2. Female no. 123211, a black and tan mouse, was mated when 57 days of age. The seventh litter was born to this female on June 6, 1943 and consisted of five individuals that averaged 1.2 gm. each at birth. Thirteen days later, June 19, 1943, another litter including six individuals was delivered. The animals of this litter were quite small, averaging 0.7 gm. each in weight. Four members of the first litter and two of the second were reared to weaning age. At this time all of the individual animals were below average weight, those of the second litter seeming to be about 1 week retarded in growth. At the present time (October 23, 1943) the male of the second group is 4.0 gm. below average weight for the males of his age group, while one of the females is 3.0 gm. and the other female is 3.2 gm. below average weight.

Case 3. Female no. 123241–2, was mated September 1, 1943 at 61 days of age. A litter of nine individuals was born on September 28, 1943. A very distinct vaginal plug was observed on September 16 and a litter of three individuals was born October 5, an interval of only 7 days from the previous birth. Four individuals of the litter of September 28th, were reared to weaning age, while two of the second litter are surviving at this time.

Case 4. A brown and tan female no. 113. On June 25, 1942 a litter of three was born. The litter weighed 3 gm. On June 27, 1942 one individual died, another died on June 30th, and the third died on July 1st. On July 11, 1942, 16 days after June 25, 1942, another litter of five individuals was born. All of the members of this second litter were reared to weaning age. This particular female gave birth to seven litters during her lifetime; however, this was the only case in which the litters were born at a shorter than 40-day interval.

Case 5. Female no 50721, black dilution, was mated at 60 days of age and the first litter was born when she was 86 days of age. On July 6, 1942 a litter of three individuals was born, the litter weighing 4.0 gm. One of these individuals died on July 8th, another on July 9th, and the last one died on July 15th. On July 18, 1942 another litter of four individuals, weighing 6.02 gm. was born. The four individuals of this last litter were reared to weaning age, Female no. 50721 had a total of eleven litters with an average time lapse of 34 days between litters, the shortest time interval outside of the case mentioned above being 22 days.

DISCUSSION

A summary of the essential facts of the five previous cases shows that in two of them, case 1 and case 4, 16 days elapsed between the delivery dates in question. In case 2 the period was 13 days; in case 5, 12 days; and in case 3, only 7 days elapsed. As examinations were made only once a day, the above figures are accurate only to within 24 hours. The observations were made on three strains of mice developed by the authors for use in their investigations. These strains have been designated: black and tan, brown and tan, and black dilution. They have been continued by brother-sister matings only. In the case of the black and tan group selection has been made for large litter size, early maturity, frequency of litters, and adult size.

Any report of superfetation assumes that a second ovulation and fertilization have taken place. There is a basis for this assumption in that, first, ovulation may be induced in pregnant animals (Friedman, '29; Snyder and Wislocki, '31; Wislocki and Snyder, '31; Wolfe, '31; Hill and Parkes, '32; and Snyder, '34), and, second, that it has been observed that estrus and copulation have occurred during pregnancy (Long and Evans, '22; Marshall, '22; Nelson, '29; Crew and Mirskaia, '30; and Watt, '31). However, no one has demonstrated the occurrence of both ovulation and copulation in a pregnant animal. as the report of Watt ('31) is beside the point in this instance. Therefore, numerous possible explanations that would fit the known and observed facts have been suggested.

Discussion of the problems of length of life and transport of the sperm, delayed insemination, delayed implantation, and variations in the estrogen content of the maternal blood stream, all these factors having been offered to explain the apparent phenomenon of superfetation, would be merely repetitious in the light of the reports of Stowell ('41) and Weichert ('42).

In discussing the case reported by him, Stowell points out the interesting temporal relationship of the two estimated dates of insemination coinciding with the length of the estrus cycle. He suggests that if ovulation occurred throughout the pregnancy under consideration, "it might well have occurred at the time the records suggest." Previous workers: King ('13) in the rat, Sumner ('16) in the mouse, and Slonaker ('34) in the rat have each reported cases of superfetation in which the interval between litters has varied from 13 to 16 days. As noted above, workers have reported the occurrence of ovulation during pregnancy and it seems entirely possible that ovulation occurred in each of these cases and that the mechanisms involved in all cases were essentially the same. It is of interest to note that four of the cases reported in this paper have occurred over a time interval of 12 to 16 days and thus would be susceptible to the same explanation as suggested by Stowell.

Weichert ('42) points out that the workers reporting cases of superfetation must explain how the older fetuses could pass the second set of implantation sites at the time of delivery without dislodging the younger embryos. This objection is of little point in the four cases, 1, 2, 4, and 5, in that here implantation of the second group of developing ova in each case could well have occurred following delivery of the first litter. In the case of 2 and 5 implantation more probably would have occurred in the upper end of the uterine horns, simply as a result of the mechanical difficulties involved.

If one assumes that the two sets of fetuses are borne in separate cornua, the difficulty involved in one set passing the other is eliminated. As the authors view the matter, however, such an assumption does not by any means solve the problems of sperm transport, implantation, and initiation of delivery. In the case of parallel embryonic development reported by Weichert ('42) the embryos of each size were confined to their separate cornua. Had these embryos gone to term no difficulty would have presented itself at this time. The question naturally arises as to the possibility of the fetuses in question in any of the cases reported here being confined to one cornua. Case 1 delivered a litter of ten which was followed 16 days later by a litter of eight; case 2 delivered two litters 13 days apart, the first litter numbering five individuals and the second litter numbering six individuals. Needless to say it does not appear likely that either of the two females carried all the members of each of their litters in separate cornua.

In the other cases, however, it seems entirely possible that the fetuses of one litter were confined to one of the cornua and the fetuses of the other litter were confined to the other cornua; particularly when we consider the number of individuals present in each of these litters, case 4 — three and five individuals, and case 5 — three and four individuals.

The authors cannot accept Weichert's broad assumption that "it seems possible that a second conception during pregancy never occurs," since by so doing they feel that they would be without adequate explanation for the occurrence of the second litter in case 1 and case 2. On the other hand, they are equally certain that case 3 represents a condition very similar to that reported by Weichert ('42). Female no. 123241–2 weighed 28 gm. previous to mating; this weight rose rapidly during pregnancy until it reached a total of 54.5 gm. on September 27, 1943. On September 28th the litter of nine was present, and the female had dropped to 37 gm. in weight. From experience, previous observations, and available data on this stock, we would have expected the weight at this time to be around 30 gm. or at the highest 32 gm. This female at this time had the appearance of an animal about a week pregnant, rather than one recently delivered. These observations were so obvious they were noted in our records on the date of September 28th, although at that time it was thought that they represented some abnormality in the condition of the female. The daily weight record of this female for the interval of September 28th to October 5th is of interest. It follows: September 29th — 38.5 gm., September 30th — 40.0 gm., October 1st — 40.0 gm., October 2nd — 42.0 gm., October 3rd — 43.0 gm., October 4th — 42.0 gm., and October 5th — 31.4 gm. The second litter, numbering three individuals, was delivered on October 5th.

In the case of this particular record it seems more probable that we are dealing with parallel embryonic development rather than with true superfetation. This opinion is based on the small number of the second litter, the close dates of parturition in the two cases, and the weight record and personal observations of the female. The vaginal plug observed on September 16th may be taken as evidence of copulation, but as is well recognized proves nothing else.

Without wishing to appear as trying to substantiate two opinions at the same time, it should be pointed out that in some respects the data available in cases 4 and 5 lend support to the idea of parallel embryonic development. Female no. 113 in case 4 delivered a litter of three, followed by a litter of five individuals. It is readily recognized that this could represent the birth of the individuals present in one cornua at different times. However, the entire history of the pregnancies of this particular female, and the weight record during the period in question, tend to substantiate our opinion that this represents a true case of superfetation. There seems to be little reason for the delayed implantation of a portion of this litter in this case.

Similarly, in case 5 we have a litter of three followed by a second litter of four individuals, which could be interpreted as birth of the members of different cornua at different times. Again the reasons for considering this a case of superfetation rest in the history of the female and the weight record at the time under consideration. In this case the female was lactating a litter of seven, born on June 15, 1942. Investigators (Brambell, '37; Kirkham, '16a, b, '18; and Enzmann, Saphir, and Pincus, '32) have shown that implantation may be delayed up to 16 days by lactation. Case 5, therefore, could readily be considered an example of delayed implantation resulting from lactation, the result being that the fetuses of the first implantation were delivered on July 6th and those of the second implantation were delivered on July 18th.

In conclusion the authors may summarize their position by stating that they believe that superfetation does occur, and is the only adequate explanation available for cases 1 and 2. On the other hand, they are equally of the opinion that many observations of "superfetation" may be incorrect because of the greater possibility of parallel embryonic development taking place than the occurrence of ovulation and fertilization — the two essential conditions for superfetation — during pregnancy. Case 3 seems to admit of no other interpretation, and cases 4 and 5 are open to either interpretation.

It is hoped that the observations reported will add to an understanding of the question of superfetation and to the general acceptance of the phenomenon.

SUMMARY

Five cases of probable superfetation in mice have been reported. It would seem that two of the cases have been shown to admit of no

other explanation. A consideration of data on weight, recurring pregnancies, and personal daily observations on the female mice in question have led to a consideration of one case as probably an example of parallel embryonic development. It is shown that the data on the other two cases may be open to interpretation as either superfetation or parallel embryonic development. The relation of these cases to some of the explanations for superfetation is discussed.

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PROGRAM FOR THE FORTY-FIRST ANNUAL MEETING OF THE AMERICAN SOCIETY OF ZOOLOGISTS

CLEVELAND, OHIO

SEPTEMBER 12, 13, 14, 1944

The Society will again hold a meeting after cancelling the regular annual meetings for the past 2 years because of transportation and other difficulties arising as a result of the war. The meeting for 1944 will be held in conjunction with Section F of the American Association for the Advancement of Science and in association with several other biological societies. All meetings for the presentation of papers and demonstrations will be held in buildings on the campus `of Western Reserve University.

Several special sessions have been arranged which will be held jointly with other societies. A symposium on ''Genes as Physiological Agents'' organized by Dr. Sewall Wright will be held in conjunction with the Genetics Society of America. A symposium on ''Parasitology in Relation to the War'' has been organized by the American Society of Parasitologists in cooperation with Section N (Medical Sciences) and the American Society of Zoologists. In addition the Society will join the American Society of Naturalists in sponsoring a symposium on ''Biology and Human Progress'' organized by Dr. Charles W. Metz.

The Biologists' Smoker will be held on the first evening of the meeting, Tuesday, September 12th, at 9:30 o'clock in the Grand Ballroom of the Hotel Statler. Admission will be by A.A.A.S. registration badge or receipt. There will be a registration desk at the Hotel Statler on the night of the smoker for those who have not had a previous opportunity to register.

The Annual Dinner of the American Society of Zoologists, to which all zoologists and friends are invited, will be held at 6:30 o'clock on Wednesday evening, Sptember 13th, in the Euclid Ballroom of the Hotel Statler. Dr. George T. Hargitt, Vice-President of Section F of the A.A.A.S. will deliver the annual address on ''What is Germ Plasm?''

The Secretary has received no notification of special reduction in railroad fares for the Cleveland meeting. However, members are advised to consult their local railroad agents in regard to possible convention or holiday rates.

As in former years, the Society is greatly indebted to The Wistar Institute for prompt publication and mailing of this program.

LOCATION OF MEETINGS

The Academy of Medicine, in which all symposia are to be held, is located on the corner of Euclid Avenue and Adelbert Road on the campus of Western Reserve University.

Adelbert Hall, in which all sessions for the reading of papers will be held, is situated on Adelbert Road a short distance from the corner of Euclid Avenue and Adelbert Road.

The Biology Building, in which the Demonstration Program of the American Society of Zoologists will be held on Wednesday afternoon, is also situated on Adelbert Road. It is the second building south of Adelbert Hall.

The Western Reserve University Campus can be reached by all through eastbound Euclid Avenue street cars which may be boarded across Euclid Avenue in front of the Hotel Statler. Leave the street car at the corner of Euclid Avenue and Adelbert Road. Facing south on Adelbert Road you will find the Academy of Medicine at the corner on your left and Adelbert Hall and the Biology Building the second and fourth building from the corner on your right.

The Hotel Statler, which will serve as headquarters for the Society, is located in downtown Cleveland at Euclid Avenue and East 12th Street. The Hotel is about 6 miles from the campus of Western Reserve University.

Those interested in bus or taxi service should make inquiries either at the Hotel Statler or at the Information Desk in Adelbert Hall.

DINNER TICKETS

Tickets for the Zoologists' Dinner on Wednesday evening will be on sale at the Information Desk in Adelbert Hall. In order to assist the local committee in making arrangements, all persons planning to attend the dinner are urged to purchase tickets as soon as possible.

LUNCHEONS

No arrangements for special Biologists' Luncheons have been made this year. However, arrangements have been made for adequate luncheon facilities at the Eldred Hall Cafeteria which is back of and between Adelbert Hall and the Biology Building. A list of other suitable restaurants in the neighborhood, giving prices and capacity, will be furnished upon request at the Information Desk.

PROGRAM

The Retiring President of the American Association for the Advancement of Science, Dr. Isaiah Bowman, President, The Johns Hopkins University, Baltimore, Maryland, will deliver his address in the Music Hall of the Cleveland Public Auditorium, Lakeside Avenue and East 6th Street at 8:15 P. M. on Monday, September 11th. The title of his address is ''Commanding our Wealth.'' Because of prevaling conditions the reception usually tendered by the local committee immediately following the address to officers and members of the Association and their guests will be omitted.

TUESDAY, SEPTEMBER 12TH

9:00 A.M.	Section A.	Joint session with the American Society of Parasitologists. Symposium on ''*Parasitology in Relation to the War.*'' Dr. Benjamin Schwartz presiding. Program on page 521. Auditorium, Academy of Medicine.
9:30 A.M.	Section B.	*Cytology and Embryology.* Papers 8 to 17. Room 35, Adelbert Hall.
2:00 P.M.		Joint session with the Genetics Society of America. Symposium on ''*Genes as Physiological Agents,*'' Dr. Sewall Wright, presiding. Program on page 522. Auditorium, Academy of Medicine.
9:30 P.M.		Biologists' Smoker. Ballroom of the Hotel Statler.

WEDNESDAY, SEPTEMBER 13TH

9:30 A.M.	Section A.	*Endocrinology.* Papers 22 to 31. Room 35, Adelbert Hall.
	Section B.	*Parasitology, General Evolution and Ecology.* Papers 32 to 39. Room 37, Adelbert Hall.
12:00 M.		Annual Business Meeting of Section F, A.A.A.S., Room 27, Adelbert Hall.
12:10 P.M.		Annual Business Meeting of the American Society of Zoologists, Room 27, Adelbert Hall.
2:00 P.M.	Section A.	*Endocrinology and General Physiology.* Papers 40 to 48. Room 35, Adelbert Hall.
2:30 P.M.	Section B.	*Demonstration Program.*[1] Papers 73 to 84. Room 30, Biology Building. (Motion pictures in Room 44, Biology Building.) See page 524.
6:30 P.M.		*Zoologists' Dinner.* Address by George T. Hargitt, Vice-President of Section F, A.A.A.S., on ''What is Germ Plasm?'' Euclid Ballroom, Hotel Statler.

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[1] Attention is directed to the demonstration program of the Genetics Society of America on Wednesday forenoon in Room 41, of the Biology Building.

Alpha Epsilon Delta, national honorary pre-medical fraternity, is arranging a special program on Pre-medical education to be held at 2:00 P. M., on Thursday, September 14th in the Herrick Room, Academy of Medicine. The influence of the war and the accelerated training program upon postwar plans for pre-medical education will be among the major topics for discussion. Further details will be found in the general program of the meeting.

THURSDAY, SEPTEMBER 14TH

9:30 A.M. Section A. *General Physiology.* Papers 49 to 61. Room 35, Adelbert Hall.
Section B. *General Morphology and Protozoology.* Papers 62 to 69. Room 37, Adelbert Hall.

2:00 P.M. Joint session with the American Society of Naturalists.
Symposium on "*Biology and Human Progress,*" Dr. Fay-Cooper Cole, presiding. Program on page 526. Auditorium, Academy of Medicine.

The Annual Dinner of the American Society of Naturalists will be held on Thursday evening, September 14th, at 6:30 P. M. in the Lattice Room of the Hotel Statler. The Presidential Address will be given by Dr. Fay-Cooper Cole, on the subject, "Human Racial Development and Migration."

LIST OF TITLES

TUESDAY MORNING SESSION, SEPTEMBER 12TH

Academy of Medicine and Adelbert Hall, Western Reserve University

This session will be held in two sections, as shown below

Section A. *Symposium* 9:00 A.M.
Auditorium, Academy of Medicine

Joint session with the American Society of Parasitologists

"PARASITOLOGY IN RELATION TO THE WAR"
Dr. Benjamin Schwartz, presiding

1. The wartime importance of tropical diseases. James S. Simmons, Brig. General, Medical Corps, U. S. Army.
2. Malaria and the war. O. R. McCoy, Major, Medical Corps, U. S. Army.
3. The development of malarial sporozoites in the vertebrate host. Clay G. Huff and Frederick Coulston, The University of Chicago.
4. Filariasis. Harold W. Brown, Columbia University.
5. Typhus fever. R. E. Dyer, National Institute of Health.
6. Development of louse powders for the armed forces. W. E. Dove, U. S. Bureau of Entomology and Plant Quarantine.
7. Parasites in relation to production of meat and other animal products in wartime. Benjamin Schwartz, U. S. Bureau of Animal Industry.

TUESDAY MORNING SESSION, SEPTEMBER 12TH

Section B. *Cytology and Embryology,* 9:30 A.M.

Room 35, Adelbert Hall

8. Stratification of the rat erythrocyte by ultracentrifuging. (10 min.) (Lantern) H. W. Beams and Eileen B. Hines, The State University of Iowa.
9. Effect of ultracentrifuging on polarity in the pollen grains of Vinca rosea. (10 min.) (Lantern) H. W. Beams and R. L. King, The State University of Iowa.
10. Distribution of mitoses in the epithelium of the cornea. (15 min.) (Lantern) Berwind Kaufmann, Helen Gay, and Alexander Hollaender, Department of Genetics, Carnegie Institution of Washington, and Industrial Hygiene Research Laboratory, National Institute of Health.
11. Electrical phenomena of avian eggs. (10 min.) (Lantern) Alexis L. Romanoff, Cornell University.
12. Relationships between spontaneous tumors of the lung and cutaneous tumors induced with ultraviolet radiation in strain A mice. (15 min.) (Lantern) Harold F. Blum, Naval Medical Research Institute.
13. The distribution of phosphatase in the fetal membranes and placenta of the guinea pig. (15 min.) (Lantern) Walter L. Hard, Department of Histology and Embryology, University of Maryland. (Introduced by Dietrich C. Smith.)

14. Migration of the germ cells of human embryos from the yolk sac to the primitive gonadal folds. (7 min.) (Lantern) Emil Witschi, The State University of Iowa.
15. The development of hybrids between Rana sylvatica and Rana pipiens. (15 min.) (Lantern) John A. Moore, Barnard College, Columbia University.
16. Causes for loss of regenerative power in adult Anura. (15 min.) (Lantern) S. Meryl Rose, Smith College.
17. The relationships of the notochord to other structures in the pharyngeal roof of the early pig embryo. (15 min.) (Lantern) James A. Miller, University of Tennessee.

TUESDAY AFTERNOON SESSION, SEPTEMBER 12TH

2:00 P. M., Auditorium, Academy of Medicine

Joint Session with the Genetics Society of America

"Genes as Physiological Agents"

Dr. Sewall Wright, presiding

1. General considerations. Sewall Wright, The University of Chicago.
2. Genic control of biochemical reactions in Neurospora. N. H. Horowitz, David Bonner, H. K. Mitchell, E. L. Tatum, and G. W. Beadle, Stanford University. (To be presented by N. H. Horowitz.)
3. Dependence of the physiological action of genes on primers. T. M. Sonneborn, Indiana University.
4. Chromosomal control of embryogenesis in Drosophila. D. F. Poulson, Yale University.

TUESDAY EVENING SESSION, SEPTEMBER 12TH

Biologists' Smoker, 9:30 P. M.; Ballroom of the Hotel Statler

WEDNESDAY MORNING SESSION, SEPTEMBER 13TH

This session will be held in two sections, as shown below

Section A. *Endocrinology,* 9:30 A. M.

Room 35, Adelbert Hall

22. Development of bone from transplanted marrow. (15 min.) (Lantern) Caroll A. Pfeiffer, Department of Anatomy, Yale University School of Medicine.
23. Experimental analysis of seasonal sexual periodicity in the female ground squirrel. (15 min.) (Lantern) Geo. Finlay Simmons, The University of Chicago and Loyola University School of Medicine.
24. On broodiness of ring doves following implants of certain steroid hormones. (15 min.) (Lantern) Oscar Riddle and Ernest Lahr, Carnegie Institution.
25. Relative effects of androgen upon the mating behavior of male rats subjected to cerebral injury or castration. (15 min.) (Lantern) Frank A. Beach, American Museum of Natural History.
26. Comparison of patterns of cyclic activity of women and the female albino rat. (15 min.) (Lantern) Edmond J. Farris, The Wistar Institute of Anatomy and Biology.
27. The vaginal smear of the rat studied with the aid of Shorr's modification of Papanicolaou's stain. (15 min.) (Lantern) Carl G. Hartman and students, University of Illinois.

28. Effects upon the thymus of prolonged massive injections of estrogens in adult female rats. (10 min.) (Lantern) James C. Plagge, University of Illinois College of Medicine.
29. Pituitary gland activity as influenced by vitamin E. (10 min.) (Lantern) Earl H. Herrick, Kansas State College.
30. The growth and gonadotropic activity of the anterior pituitary of the cockerel. (15 min.) (Lantern) W. R. Breneman, Indiana University.
31. Time and quantity relationships in hormonal sex reversal of Rana clamitans larvae. (8 min.) (Lantern) Beatrice Mintz, The State University of Iowa. (Introduced by Emil Witschi.)

WEDNESDAY MORNING SESSION, SEPTEMBER 13TH

Section B. *Parasitology, General Evolution and Ecology,* 9.30 A. M.

Room 37, Adelbert Hall

32. Granular structures in the inclusion bodies of the lymphocystis virus disease of fish. (15 min.) (Lantern) J. Richard Weissenberg, Department of Histology, Middlesex University School of Medicine.
33. Studies on the life history of the oribatid mite Galumna sp., intermediate host of Moniezia expansa. (15 min.) Horace W. Stunkard, New York University.
34. Human evolution and education: The timing of specialization. (15 min.) Hans Elias, Middlesex University.
35. Speciation in the American genus Mustela. (15 min.) (Lantern) E. R. Hall, University of Kansas.
36. Hens that are members of as many as four flocks may maintain a different social status in each. (15 min.) (Lantern) Marjorie B. Douglis, Whitman Laboratory of Experimental Zoology, The University of Chicago. (Introduced by W. C. Allee.)
37. The social organization resulting from the introduction of pairs of young chicks to a small flock of chickens and pigeons. (12 min.) Howard H. Vogel, Jr., Wabash College.
38. Growth curves and changes in form of two Coleopterous larvae (Epilachna corrupta Muls.) and (Laemopholeus minutes Oliv.) (15 min.) (Lantern) Nellie M. Payne, American Cyanamid Company.
39. Nomadism in the swarm-raiding army ants as an instance of animal migration. (15 min.) (Lantern) T. C. Schneirla, American Museum of Natural History and New York University. (Introduced by William Etkin.)

WEDNESDAY MORNING SESSION, SEPTEMBER 13TH

BUSINESS MEETING

The Annual Business Meeting of Section F, A.A.A.S. will be held Wednesday, September 13th, 12 M., in Room 27, Adelbert Hall. *The Annual Business Meeting of the American Society of Zoologists* will be held in the same room at 12:10 P. M., immediately after the meeting of Section F.

WEDNESDAY AFTERNOON SESSION, SEPTEMBER 13TH

This session will be held in two sections, as shown below

Section A. *Endocrinology and General Physiology,* 2:00 P. M.

Room 35, Adelbert Hall

40. An organizer of environmental origin, for the secondary sexual organ system of Drosophila melanogaster. (15 min.) (Lantern) John W. Gowen, Iowa State College.

41. The influence of the male cichlid fish, Tilapia macrocephala on the spawning frequency of the female. (15 min.) (Lantern) Lester R. Aronson, American Museum of Natural History. (Introduced by Charles M. Breder, Jr.)
42. The role of the corpora allata in the development of Leucophae maderae (Orthoptera). (15 min.) (Lantern) Berta Scharrer, Department of Anatomy, Western Reserve University.
43. Retinal extracts and growth in male rats. (15 min.) Ludvig G. Browman, Montana State University.
44. Influence of thiourea on organ weights and plasma proteins of the rat. (15 min.) (Lantern) James H. Leathem, Rutgers University.
45. Involution of the thymus in young rats with a transplanted reticulum cell sarcoma. (15 min.) (Lantern) Eleanor H. Yeakel and Edmond J. Farris, The Wistar Institute of Anatomy and Biology.
46. Color changes in regenerated tails of Anolis carolinensis. (12 min.) (Lantern) Francis H. Wilson, Tulane University.
47. Microbiological assay of nicotinic acid synthesized by Chilomonas paramecium. (12 min.) (Lantern) E. L. Powers and P. S. Stokely, University of Notre Dame. (Introduced by Rainer Zangerl.)
48. Bioassay of ultraviolet treated hog sausage. (10 min.) (Lantern) Edgar P. Jones and Joshua Stampfer, University of Akron.

WEDNESDAY AFTERNOON SESSION, SEPTEMBER 13TH

Section B. DEMONSTRATION PROGRAM

Beginning at 2:30 P. M.; *General Demonstrations*, Room 30, Biology Building.

(Motion pictures in Room 44, Biology Building.)

Motion picture demonstrations

73. Additional observations on mating behavior of the sage grouse. John W. Scott, University of Wyoming. (Motion pictures in Kodachrome.)
74. The hatching process in the bobwhite quail. Howard H. Vogel, Jr., and J. P. Scott, Wabash College. (Motion pictures in Kodachrome.)
75. The analysis of prostasia (social control and leadership) in a small flock of sheep. J. P. Scott, Wabash College. (Motion pictures in Kodachrome.)

(Motion picture demonstrations will be repeated in Room 44, Biology Building, at 4:00 P. M.)

General Demonstrations

76. Demonstration of the vaginal smear cycle in the ground squirrel. Geo. Finlay Simmons, The University of Chicago and Loyola University School of Medicine.
77. Sexual cycle of the male long-tailed weasel. Philip L. Wright, Montana State University.
78. Mammary glands of rats from The Wistar Institute. Virgene W. Kavanagh and Ralph P. Reece, New Jersey Agricultural Experiment Station.
79. Some features of the anatomy and physiology of Anolis carolinensis. Francis H. Wilson, Tulane University.
80. The growth rate of tadpoles raised in various dilutions of Ringer's solution. William Etkin, American Museum of Natural History and College of the City of New York.
81. The integument, coloration, and color change of some anurans. Hans Elias, Middlesex Veterinary School.

82. The development of melanomas from macromelanophores in different body regions under genetic control. Myron Gordon, New York Zoological Society.
83. A rapid method for demonstrating mammalian somatic mitoses. Helen Gay and Berwind Kaufmann, Industrial Hygiene Research Laboratory, National Institute of Health, and Department of Genetics, Carnegie Institution of Washington.
84. Phase-difference microscopy of living unstained protoplasm. Oscar W. Richards, Research Division, Spencer Lens Company, Buffalo, N. Y.

WEDNESDAY EVENING, SEPTEMBER 13TH, 6:30 P. M.

Zoologists' Dinner, Euclid Ballroom of the Hotel Statler

Address by Dr. George T. Hargitt
Vice-President of Section F of the A.A.A.S., on
"What is Germ Plasm?"

(Open to all Zoologists and friends.)

THURSDAY MORNING SESSION, SEPTEMBER 14TH

This session will be held in two sections, as shown below

Section A. *General Physiology,* 9:30 A.M.

Room 35, Adelbert Hall

49. Hemodynamic and respiratory effects of crotomic aldehyde in dogs. (7 min.) (Lantern) Theodore Koppanyi, Department of Pharmacology and Materia Medica, School of Medicine, Georgetown University.
50. The effect of propyl aldehyde in dogs. (8 min.) (Lantern) Theodore Koppanyi, Department of Pharmacology and Materia Medica, School of Medicine, Georgetown University.
51. The influence of glycotropic substances on survival of the primitive respiratory center of the isolated rat head. (15 min.) (Lantern) Wm. A. Hiestand and Robert D. Tschirgi, Purdue University.
52. The influence of certain aromatic and aliphatic sympathomimetic amines on respiratory center survival. (15 min.) (Lantern) Robert D. Tschirgi and Wm. A. Hiestand, Purdue University.
53. Physiological conditions affecting the electrical activity of the brain. (5 min.) (Lantern) T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia.
54. Models of the action current in cholinergic and adrenergic nerves. (5 min.) (Lantern) R. Beutner and T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia.
55. The rate of healing of skin abrasions indicated by the positive wound potential. (5 min.) (Lantern) T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia.
56. Correlation of electrical and chemical changes in the dark-adapted insect eye. (15 min.) (Lantern) Verner John Wulff and Theodore Louis Jahn, The State University of Iowa.
57. The action of the gene a on the tryptophane metabolism of Ephestia kühniella. (15 min.) (Lantern) Ernst Caspari, Lafayette College, Easton, Pa.
58. A method of recording contraction by means of electronic differentiation. (5 min.) (Lantern) Alexander Sandow, Washington Square College of Arts and Science, New York University.
59. The effect of activity on the twitch of frog skeletal muscle. (10 min.) (Lantern) Alexander Sandow (with the technical assistance of A. G. Karczmar), Washington Square College of Arts and Science, New York University.

60. Effect of hydrogen peroxide on the resistance and capacitance of frog skin. (15 min.) (Lantern) Gordon Marsh, The State University of Iowa.
61. Heat activation, inhibition, and injury of protyrosinase and tryosinase. (15 min.) (Lantern) Joseph Hall Bodine, Theodore Newton Tahmisian and David Leal Hill, The State University of Iowa.

THURSDAY MORNING SESSION, SEPTEMBER 14TH

Section B. *Morphology and Protozoology,* 9:30 A. M.

Room 37, Adelbert Hall

62. Contribution to the osteology of the postcranial skeleton of the Amphisbaenidae. (12 min.) (Lantern) Rainer Zangerl, University of Notre Dame.
63. Numerical and regional distribution of taste buds on the tongue of the opossum, with particular reference to those in the fungiform papillae. (15 min.) (Lantern) Rush Elliott, Ohio University and E. B. Morris Biological Farm.
64. The granular cells of the juxtaglomerular apparatus. (12 min.) (Lantern) F. W. Dunihue, Medical College, University of Vermont.
65. Phase-difference microscopy for transparent objects. (15 min.) (Lantern) A. H. Bennett, Research Division, Spencer Lens Company, Buffalo, N. Y. (Introduced by Morden G. Brown.)
66. Phase-difference microscopy for living unstained protoplasm. (15 min.) (Lantern) Oscar W. Richards, Research Division, Spencer Lens Company, Buffalo, N. Y.
67. Serologic differentiation of the three species of paramecia in the aurelia group. (12 min.) (Lantern) James A. Harrison and Elizabeth H. Fowler, Temple University. (Introduced by E. A. Dennis.)
68. The utilization of amino acids by the ciliate Tetrahymena geleii. (15 min.) (Lantern) George W. Kidder, Brown University.
69. The food-vacuole in the Peritricha, with special reference to the hydrogen-ion concentration of its content and of the cytoplasm. (15 min.) (Lantern) S. O. Mast and W. J. Bowen, The Johns Hopkins University and the Marine Biological Laboratory.

THURSDAY AFTERNOON SESSION, SEPTEMBER 14TH

2:00 P. M., Auditorium, Academy of Medicine

Joint Session with the American Society of Naturalists

"BIOLOGY AND HUMAN PROGRESS"

Dr. Fay-Cooper Cole, presiding

1. Biology and the public mind. C. V. Taylor, Stanford University.
2. Plants and the material basis of civilization. E. W. Sinnott, Yale University.
3. The rehabilitation of biological research and education in war stricken countries. Robert Chambers, Jr., New York University.

PAPERS PRESENTED BY TITLE

Cellular Physiology

85. The survival of human spermatozoa in solutions of penicillin. Landrum B. Shettles, The Johns Hopkins Hospital.
86. A selective lethal effect of penicillin on sarcoma cells growing with normal tissue in roller tube cultures. Ivor Cornman, The Wistar Institute of Anatomy and Biology.

87. The effects of potassium cyanide, potassium arsenite, and ethyl urethane on respiration in Pelomyxa carolinensis. D. M. Pace and W. H. Belda, University of Nebraska and St. Francis Seminary.
88. The production of multipolar mitoses in normal somatic cells of embryonic chick tissue grown in vitro. E. Frances Stilwell, Woman's Medical College of Pennsylvania.
89. Possible conversion of chromonucleic acid into plasmonucleic acid during atypical spermiogenesis of Viviparus malleatus Reeve. Arthur W. Pollister and George I. Lavin, Columbia University and The Rockefeller Institute for Medical Research.

Ecology

90. Relation of diatoms to salinity in Chesapeake Bay. R. P. Cowles and C. E. Brambel, The Johns Hopkins University and Mercy Hospital.
91. An ecological and taxonomic study of the marine intertidal mites of Long Island Sound. Irwin M. Newell, Yale University. (Introduced by G. E. Hutchinson.)
92. Age-groups and longevity in Turdus migratorious L. Donald S. Farner, University of Wisconsin.
93. Number of progeny related to social position in a flock of chickens. A. M. Guhl, D. C. Warren, and L. F. Payne, Kansas State College.

Embryology

94. Agglutination of starfish sperm by homologous egg water. Charles B. Metz, Wesleyan University. (Introduced by Albert Tyler.)
95. Regeneration in the frog. C. S. Thornton, Kenyon College.
96. Induction of scar tissue and cartilage in limbs of lizards after amputation. Lucie Welles Barber, Smith College. (Introduced by S. Meryl Rose.)
97. The production of poliferative nodules in embryonic tissue by scrub typhus rickettsiae. Captain Howard L. Hamilton, Sn. C., Division of Virus and Rickettsial Diseases, Army Medical School, Washington, D. C.
98. Subcutaneous vs. dermal melanophores. Hans Elias, Middlesex Veterinary School.
99. The effect of exposure of temperature of 5–10°C. on the survival and differentiation of embryonic thyroid tissue cultures. Esther Carpenter, Smith College and The Ohio State University.
100. Cyclopia. A. M. Reese, West Virginia University.
101. Parallelism of the determination of scalloping and plexation in the wings of Drosophila. Richard B. Goldschmidt, University of California.
102. Phenogenetic studies of the aristapedia alleles of Drosophila pseudoobscura. Claude A. Villee, University of North Carolina.

Endocrinology

103. The thyrotrophic potency of the pituitary of the albino mouse. A. Elizabeth Adams and Arlene M. Mothes, Mount Holyoke College.
104. Concentration of urinary hypophyseal hormones by ultrafiltration. Aubrey Gorbman, Wayne University.
105. Pituitary changes in aging capons. Fernandus Payne, Indiana University.
106. Possible control of the lateral vaginal canal in the opossum during reproduction. Olin E. Nelsen, University of Pennsylvania.
107. The effect of some steroid hormones on the seminal vesicles of the mouse. H. J. Clausen, University of Colorado School of Medicine.

108. Studies on the efficacy of desoxycorticosterone acetate in adrenalectomized rats on — (A) a low sodium chloride diet; (B) a diet deficient in cystine. **Wilburn J. Eversole, The Rice Institute.**
109. Action of desoxycorticosterone acetate in the immature mouse. **H. D. Slobodien and J. H. Leathem, Rutgers University.**
110. Effects of thiourea, thiouracil and estrogens on resistance of rats to lowered barometric pressures. E. D. Goldsmith, Albert S. Gordon, and **Harry A. Charipper, Washington Square College of Arts and Science, New York University.**
111. Feather growth rates in thyroidectomized brown Leghorn fowl. **Ben B. Blivaiss and L. V. Domm, Whitman Laboratory of Experimental Zoology, The University of Chicago.**
112. The effect of thyroxin in the thiouracil-treated brown Leghorn capon. **Mary Juhn, University of Maryland.**
113. Paraxanthine and thyroid function. Albert S. Gordon, **Harry A. Charipper and E. D. Goldsmith, Washington Square College of Arts and Science, New York University.**
114. Phosphorus turnover in brown fat as demonstrated by radio-active phosphorus. **Jae L. Littrell, Dorothy Martin and Carl G. Hartman, University of Illinois.**
115. Acquired resistance to water intoxication. **Mildred Liling and Robert Gaunt, Washington Square College of Arts and Science, New York University.**
116. The occurrence of burst atretic follicles in the class Aves. **David E. Davis, United States Public Health Service.**

General Evolution

117. Natural hetero-agglutinins in lobster serum. **Albert Tyler and Charles B. Metz, California Institute of Technology and Wesleyan University.**
118. Systematic relationship in animals. **Alan Boyden, Rutgers University.**

General Physiology

119. Protein determination in the presence of ammonium sulfate. **Lyle V. Beck, Hahnemann Medical College of Philadelphia.**
120. The distribution of alkaline phosphatase in the fetal membranes and placenta of the guinea pig. **Walter L. Hard, Department of Histology and Embryology, University of Maryland. (Introduced by Dietrich C. Smith.)**
121. Death of dormant protoplasm. B. J. Luyet and P. M. Gehenio, **St. Louis University and Biodynamica Laboratory.**
122. Reorganization and restoration of inductive power in pulverized papillae in brown Leghorn capons. Hsi Wang, Whitman Laboratory of Experimental Zoology, The University of Chicago. **(Introduced by F. R. Lillie.)**
123. Evidence of control by saddle epidermis of axial growth rate in feathers of composite breast-saddle origin in brown Leghorn capons. Hsi Wang, Whitman Laboratory of Experimental Zoology, The University of Chicago. **(Introduced by F. R. Lillie.)**
124. The rate of pulsation of the posterior contractile vacuole of Paramecium woodruffi and Paramecium calkinsi. **John A. Frisch, S. J. Canisius College.**
125. The rate of adaptation of Paramecium caudatum to sea water. (Woods Hole, Mass.). **John A. Frisch, S. J. Canisius College.**
126. Further observations on factors influencing the hypoxic survival of mice subjected to barometric decompression. Wm. A. Hiestand and Helen Rogers Miller, Purdue University.
127. Vitamin deficiency and "altitude" tolerance in rats. **Harry A. Charipper, E. D. Goldsmith** and Albert S. Gordon, Washington Square College of Arts and Science, New York University.

128. The persistence of a thymus remnant in aged rats. Edmond J. Farris and Eleanor H. Yeakel, The Wistar Institute of Anatomy and Biology.
129. Seasonal and diurnal variation in erythrocyte count in the domestic fowl. Elsie Taber and L. V. Domm, Whitman Laboratory of Experimental Zoology, The University of Chicago.

Morphology

130. Sexual dimorphism in sea-urchins. Albert Tyler, California Institute of Technology.
131. The anatomy of the female American lac insect, Tachardiella larrea. Harold S. Colton, Museum of Northern Arizona.
132. On the origin of the nervous system of vertebrates. F. H. Pike, Columbia University.
133. Percentage weights of the major divisions of the brain in several species of animals. Homer B. Latimer, University of Kansas.

Parasitology

134. Duodenal mucus and age resistance to ascarids. J. E. Ackert and L. P. Frick, Kansas State College.
135. The parasites of the Liopelmidae (Amphibia – Salientia – Amphicoela), and of the Pipidae (Amphibia – Salientia – Opisthocoela). A. C. Walton, Knox College.
136. The parasites of the Discoglossidae (Amphibia – Salientia – Opisthocoela). A. C. Walton, Knox College.
137. The parasites of the Pelobatidae (Amphibia – Salientia – Anomocoela). A. C. Walton, Knox College.

Protozoology

138. The early history of the genus Paramecium. Lorande Loss Woodruff, Yale University.
139. Exchange of cytoplasm at conjugation in Paramecium aurelia, variety 4. T. M. Sonneborn, Indiana University.
140. The growth of Tetrahymena geleii in thiamine-free media. George W. Kidder and Virginia C. Dewey, Brown University.
141. The apparent need of Glaucoma piriformis for calcium and iron. R. P. Hall and W. B. Cosgrove, New York University.

ABSTRACTS

TABLE OF CONTENTS

Papers Read

Sections		*Abstract No.*	*Page No.*
Cytology and Embryology	Sect. B	8– 17	531
Endocrinology	Sect. A	22– 31	534
Endocrinology and General Physiology	Sect. A	40– 48	538
General Physiology	Sect. A	49– 61	542
Morphology and Protozoology	Sect. B	62– 69	546
Parasitology, General Evolution and Ecology	Sect. B	32– 39	549

Papers Presented by Demonstration

Motion Pictures	73– 75	552
General Demonstrations	76– 84	553

Papers Presented by Title

Cellular Physiology	85– 89	556
Ecology	90– 93	558
Embryology	94–102	559
Endocrinology	103–116	562
General Evolution	117–118	568
General Physiology	119–129	568
Morphology	130–133	573
Parasitology	134–137	574
Protozoology	138–141	576
Author Index		579

ABSTRACTS

PAPERS PRESENTED IN PERSON

Cytology and Embryology (Sect. B)

8. STRATIFICATION OF THE RAT ERYTHROCYTE BY ULTRACENTRIFUGING. H. W. Beams and Eileen B. Hines, The State University of Iowa. (Lantern; 10 min.)

The spleen of the rat was centrifuged at 400,000 × gravity for 30 minutes. It was then fixed in Champy's solution and stained in Heidenhain's hematoxylin and in Mallory's triple stain.

The erythrocytes show a distinct stratification. The centrifugal end of the cell stains dark in hematoxylin. With Mallory's stain three distinct layers are visible; an orange layer at the centrifugal end, a red layer near the center, and a light blue layer at the centripetal end. These results indicate that the rat erythrocyte contains at least three substances that differ in their relative specific gravity and staining reactions when stratified.

9. EFFECT OF ULTRACENTRIFUGING ON POLARITY IN THE POLLEN GRAINS OF VINCA ROSEA. H. W. Beams and R. L. King, The State University of Iowa. (Lantern; 10 min.)

When centrifuged at 20,000 times gravity, about 70% of the pollen tubes of Vinca rosea germinate at the centrifugal side. In those tubes which appear at other than the centrifugal pole, further growth is directed by the centrifugal force. Centrifuging tends to overcome the ''group effect.'' Displacement of hormones, enzymes, or substrate, or the establishment of a physiological polarity by such displacement are possible explanations of these results.

10. DISTRIBUTION OF MITOSES IN THE EPITHELIUM OF THE CORNEA. Berwind Kaufmann, Helen Gay and Alexander Hollaender, Department of Genetics, Carnegie Institution of Washington, and Industrial Hygiene Research Laboratory, National Institute of Health. (Lantern; 15 min.)

In the course of investigations of the effects of ultraviolet radiation on the dividing cells of the epithelium of the cornea of the mammalian eye a method was developed for making rapid counts of these cells in flat preparations. In order to measure the disturbance caused by the radiation, it was necessary to determine the range of variability in the frequency of mitoses within a single cornea and between the two corneas of one animal. An analysis of the range of this variability in the rat and in the rabbit showed that counts made along a meridional strip across the entire cornea furnish a more reliable index of the frequency in the entire cornea than counts made in isolated regions. Counts made on two or more strips within the same cornea fall within the range of the sampling error, as determined by the χ^2 method. There may be a considerable difference in the frequency of mitoses between the two eyes of an animal; such differences must be considered in experimental work where a treated cornea is compared with the other cornea of the same animal used as a control. The proportions of the various stages of mitosis were found to be relatively constant from preparation to preparation, so that counts made on the more conspicuous stages, such as metaphase and anaphase, furnish under certain conditions a reliable index of the overall frequency.

11. ELECTRICAL PHENOMENA OF AVIAN EGGS. Alexis L. Romanoff, Cornell University, Ithaca, New York. (Lantern; 10 min.)

Observation of Davy (1860) on polarizable "electrical action" between the yolk and white marks the beginning of studies of electrical phenomena of birds' eggs. Much later, however, Herman and Gendre (1884) presented quantitative evidence that the electromotive power of the embryo is positive to the yolk, and that it increases during the first few days of incubation.

The most significant contribution in this field was made by Waller (1902-'03) who applied the bioelectric potential measurements between the blastoderm and the opposite pole of eggs in diagnosing the presence or absence of a living embryo. Vorontzov and Serguyevskii (1933) detected the potential through the shell of the intact egg and after four hours of incubation were able to differentiate a fertile egg from infertile, and a living embryo from a dead one.

Using Burr's technique (Burr, Lane and Nims, 1936) in an improved form measurable differences in bioelectric potentials between fertile and infertile fresh hens' eggs were demonstrated by Romanoff and Cottrell (1939). The resulting average values were about 0.8 and 0.2 millvolt for fertile and infertile eggs, respectively.

To further the work, attempts have been made to increase the bioelectric potentials of the fertilized blastoderm by physical radiation. It was found that doses of x-rays of about 250 r stimulated the blastoderm with an increase in bioelectric potentials of about 250 per cent (Romanoff and Bless, 1943). Similarly, exposure to filtered ultraviolet rays at λ 3560Å increased the bioelectric potentials only about 60 per cent (Romanoff, 1943).

12. RELATIONSHIPS BETWEEN SPONTANEOUS TUMORS OF THE LUNG AND CUTANEOUS TUMORS INDUCED WITH ULTRAVIOLET RADIATION IN STRAIN A MICE. Harold F. Blum, Naval Medical Research Institute. (Experiments carried out at the National Cancer Institute.) (Lantern; 15 min.) The opinions or assertions contained herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Navy Department.

Cutaneous tumors were induced in strain A mice by exposing them to repeated doses of ultraviolet radiation. This strain develops pulmonary tumors spontaneously. The incidence of pulmonary tumors was less in mice exposed to ultraviolet radiation than in unexposed mice. Had a permeant carcinogen been formed in the skin by the ultraviolet radiation the incidence of pulmonary tumors should have been increased. The contrary finding is evidence against the sterol conversion hypothesis of carcinogenesis by ultraviolet radiation.

The curve of cumulative pulmonary tumor incidence is distorted in the mice with cutaneous tumors in a manner indicating that in selecting individuals with cutaneous tumors there is a tendency to select individuals with pulmonary tumors. The distribution found seems best explained by the existence of several factors influencing tumor development, at least one of which has a similar effect on tumors developing in different tissues of the same individual, but varies in potency among individuals.

The decreased incidence of pulmonary tumors is partly explained by selection for cutaneous tumors before pulmonary tumors have time to develop. Not all the decreased incidence is due to selection, however. Uultraviolet radiation must reduce pulmonary tumor incidence in some indirect way, possibly by curtailing food intake.

13. THE DISTRIBUTION OF PHOSPHATASE IN THE FETAL MEMBRANES AND PLACENTA OF THE GUINEA PIG. Walter L. Hard, Department of Histology and Embryology, University of Maryland. (Lantern; 15 min.) (Introduced by Dietrich C. Smith).

The histological distribution of phosphatase (Gomori's method) has been analyzed in the placenta and associated membranes of gestation ages from 11 days to birth. Within the recently implanted blastocyst phosphatase occurs solely in the endodermal cells surrounding the embryonic disc, and those destined to form the yolk-sac. The superficial zone of decidual cells, surrounding the blastocyst, is negative in reaction but a deeper, more prominent zone is markedly positive.

Throughout the gestation period the labyrinth zone has a heavy concentration of phosphatase in contrast to the spongy zone which is consistently negative. The sub-placenta, allantoic vessels and mesenchyme, and giant cells are negative. In the ''junctional'' zone an occasional multinucleated cell mass shows a slight positive reaction. The decidual layer as a whole is negative but occasional cells show a prominent positive reaction.

Those cells of the endodermal yolk-sac which surround the uterus are strongly positive up to the 45–50 day period after which time cells in localized areas become negative and by 60–65 days the entire epithelium is negative. The endodermal yolk-sac cells from the region of the sinus terminalis and extending over the surface of the placenta are always negative. The amnion and chorion are negative.

Quantitative data on phosphatase concentrations are being accumulated and this, together with the histological distribution, considered in terms of the possible relationships with placental metabolism.

14. Migration of the germ cells of human embryos from the yolk sac to the primitive gonadal folds. Emil Witschi, The State University of Iowa. (Lantern; 7 min.)

Twenty-three human embryos ranging from the 13-somite to the 8 mm. stage served for a study of the origin of the germ cells and their history up to the formation of the primitive sex glands. In the youngest embryo all germ cells are in the endoderm of the yolk sac near the allantoic evagination, which indicates that they either have an endodermal origin or arise from primitive stem cells which also are the source of the endoderm. In embryos from 13 to 20 somites they become transferred from the yolk sac to the hind-gut. Less than half remain temporarily in the endodermal epithelium. The larger number move into the mesenchyme. During the second phase of migration, beginning in embryos of 25 mm., the germ cells leave the gut, ascend through the mesentery and advance laterally toward the mesonephric folds. They form lobate and filiform pseudopodia and give signs of lytic action. It is concluded that migration is accomplished by active movements of the individual cells and that the course of their migrations becomes oriented by a specific substance emitted by the peritoneum of the prospective gonadal region. At their arrival in the gonadal folds the germ cells become enclosed in individual follicle cells. This marks the end of autonomous movements. The number of germ cells increases steadily through mitotic cell divisions. No facts and no convincing theoretical arguments in favor of secondary germ cell formation during the period covered by this investigation were found.

15. The development of hybrids between Rana sylvatica and Rana pipiens. John A. Moore, Barnard College, Columbia University. (Lantern; 15 min.)

When eggs of Rana sylvatica are fertilized with sperm of Rana pipiens the hybrids develop normally at the maternal rate throughout cleavage and blastula stages but are unable to gastrulate. These hybrids remain alive until the controls have completed gastrulation and then cytolysis occurs. The hybrids of the reciprocal cross, Rana pipiens eggs fertilized with Rana sylvatica sperm, likewise develop normally at the maternal rate to the beginning of gastrulation. These hybrids remain alive, with little or no further differentiation, until the controls are free swimming tadpoles with a transparent cornea (stage 21). The dorsal lip appears and some invagination may occur. In the majority of cases the hybrids remain as early gastrulae and cilia which appear on the pigmented cells represent the only noticable differentiation. In a few cases a tiny embryo is produced entirely from the material immediately above the dorsal lip. These exceptional embryos, which develop on top of a large mass of unorganized and extra-embryonic cells, may have a fairly complete set of embryonic structures.

16. CAUSES FOR LOSS OF REGENERATIVE POWER IN ADULT ANURA. S. Meryl Rose, Smith College. (Lantern; 15 mn.)

At the time of metamorphosis when frogs are losing the ability to regenerate limbs, a number of tissue changes which better adapt the animals to a terrestrial habitat are occurring. Some of these changes also prevent limb regeneration. Skin becomes thicker, especially the dermis, and bone more sturdy. It so happens that the compact bundles of dermal fibers and the thicker bone are resistant to dedifferentiation and begin to disappear very slowly. Instead of being converted to mesenchyme as are the softer tissues, e.g. muscle, most of the bone and dermis remain intact. Consequently the anomalous condition of old tissue in a blastema results. The bone remains as a core through the blastema and dermis surrounds it. Such a blastema does not develop into a limb but is converted to fibrous scar and cartilage. The scar tissue, which is similar to dermal fiber, arises beneath the dermis, and cartilage forms around the old bone. Apparently blastema cells in the vicinity of old bone are induced to form cartilage and those close to dermis become fibroblasts. The blastemas of animals which regenerate normally, e.g. tadpoles and salamanders, lie distal to all organized tissue and are not dominated by just two old tissues. Instead, a normal blastema lies in a field of inductors emanating from many old tissues at its base. Normal regeneration, then, is prevented by asynchronous dedifferentiation and subsequent induction of too few new tissues by the old tissues which have resisted dedifferentiation.

17. THE RELATIONSHIPS OF THE NOTOCHORD TO OTHER STRUCTURES IN THE PHARYNGEAL ROOF OF THE EARLY PIG EMBRYO. James A. Miller, University of Tennessee. (Lantern; 15 min.)

Studies on over 225 sagittally sectioned pig embryos, chiefly between five and seventeen millimeters length gave the following findings:

1. Contacts between prechordal plate and Rathke's pocket decreased from almost 55% in embryos of 5–6 mm. to less than 10% in those 15–17 mm. Between notochord and Sessel's pocket a decrease in frequencies of contacts was from 30% to about 5%; between notochord and rest of pharyngeal roof from almost 50% to 13%.

2. Contact areas between notochord and entoderm showed evidences of proliferation by both chorda and epithelium. Thickening of Rathke's pocket occurred in areas of contact with prechordal plate. However, no true organizing action was observed and no evidence of entodermal contributions to the pituitary (M. Miller) were seen.

3. Measurements of distances between neural tube and oropharyngeal epithelia were used as indices of mesenchymal activity. Between 5 and 15 mm. the distance between preoptic recess and ectoderm increased almost 40 ×, lending support to the view that the early elongation of Rathke's pocket is largely passive. Distance from metencephalic floor to notochord increased almost 15 × during the same interval. By contrast, no increase in mesenchyme occurred between notochord and pharyngeal roof from 5 to 10 mm.; from 10 to 15 mm. the increase was about 4½ ×.

4. In nine cases of chordal fracture, five showed entodermal contacts at both ends of the fracture, four at one end only. The time of appearance and loci of these fractures correlated with observed differences in mesenchymal increase.

5. The pharyngeal bursa of Sus develops behind regions of contact between chorda and pharynx, differing in this respect from conditions described for Homo (Huber, Snook).

Endocrinology (Sect. A)

22. DEVELOPMENT OF BONE FROM TRANSPLANTED MARROW. Carroll A. Pfeiffer, Department of Anatomy, Yale University School of Medicine. (Lantern; 15 min.)

Bone marrow from the femur was transplanted to the anterior chamber of the eyes of normal female and normal and castrated male mice of the A strain. The normal females and half of the normal and castrated males received 16.6 μg. of estradiol benzoate weekly. At autopsy, after 60 days, organized bone had formed from the marrow transplants in both intact and castrated males whether estrogen had been injected or not and did so about equally well in all but the normal males, where the grafts did not take as well. To rule out stimulation by the anterior chamber of the eye, marrow grafts were made into the testis in 20 males and subcutaneously into the ear in another 20 males. In the former site resistance to grafting is very slight, while in the latter it is rather high. Half of the animals in each group received 16.6 μg. of estradiol benzoate weekly, and all animals were autopsied after 70 days. The grafted marrow reticulum cells formed bone in the testis and did so equally well whether the host had received estrogen or not. The grafting sites in the ears were not found. Presumably the marrow reticulum cells had become tissue wandering cells and had migrated from the area. It is concluded that where the resistance to grafting is low grafted marrow reticulum cells form bone.

23. EXPERIMENTAL ANALYSIS OF SEASONAL SEXUAL PERIODICITY IN THE FEMALE GROUND SQUIRREL. Geo. Finlay Simmons, The University of Chicago and Loyola University School of Medicine. (Lantern; 15 min.)

Over 1000 female ground squirrels were captured and many cage-born litters reared. Age was determined by nipples, sexual activity by vulvar changes, ovarian and accessory cycles by seven stages of vaginal smears, and embryo age by palpation during gestation (28 days). Animals hibernate October to April, breed once annually, seldom mate in captivity.

Reproductive organs from 300 field females demonstrate estrogens increasing December through April, dropping after coitus, rising after midpregnancy, falling sharply at parturition, and declining more slowly to September. Tissues from 300 laboratory controls show little seasonal activity, few reaching estrus in February.

Anestrous ovaries, July to December, appear inactive, but further involution of accessories follows spaying. Accessories respond immediately to estrogens. Gonadotropins readily stimulate ovaries to follicular and estrogenic activity, secondarily enlarge accessories.

Anterior pituitaries of 150 females, assayed in rats and mice, showed gonadotropic potency in early and full estrus, during last three weeks of pregnancy, and two months after spaying in February and August. Gonadotropins circulated in autumn immatures, in April puberals and spayed prepuberals.

Food, activity, light, dark, and cool experiments were negative; but cold-dark isolation in midsummer induced early hibernation, with estrus by September to December — prolonged hibernation attenuating pre-estrous stages.

These observations suggest female ground squirrels are sexually inactive in summer and fall because of low pituitary activity, kept down by ovarian hormones, since if ovaries are rendered inactive — by removal or torpor — the pituitary is released to produce increased gonadotropins, leading to slow onset of another sex cycle.

24. ON BROODINESS OF RING DOVES FOLLOWING IMPLANTS OF CERTAIN STEROID HORMONES. Oscar Riddle and Ernest L. Lahr, Carnegie Institution. (Lantern; 15 min.)

Ring doves of both sexes and of three age levels were used to test the ability of implanted pellets of certain steroid hormones to induce broodiness and to release prolactin from the pituitaries of the treated birds.

Seventeen untreated pairs of mature or adolescent doves served as controls; these, together with 5 pairs treated with pellets of estrone (44 birds), did not become broody nor did their crop-sacs increase in size.

Paired adult and adolescent birds of either sex treated with progesterone or desoxycorticosterone acetate, and similar females treated with testosterone propionate, became broody in 43 of 62 tests. Twenty-one of these broody birds were killed while broody, or while feeding young, and proof of enlargement of their crop-sacs was obtained by weighing these organs; 29 of these responding birds fed or reared young, thus proving both the functional state of their crop-sacs and the antecedent release of prolactin under the stimulus of the effective steroids. These steroids were nearly or quite ineffective in young doves and in isolated (unpaired) mature doves.

Those steroid hormones which were earlier observed by Riddle, Lahr and Bates to promote maternal behavior in rats were here shown to be effective in inducing broodiness in doves. This effect in doves was produced by steriods which caused a concurrent release of prolactin from the dove's own pituitary but not by steroids which failed to do so. These results provide further evidence for a specific role of prolactin in the initiation of broodiness and parental care.

25. RELATIVE EFFECTS OF ANDROGEN UPON THE MATING BEHAVIOR OF MALE RATS SUBJECTED TO CEREBRAL INJURY OR CASTRATION. Frank A. Beach, American Museum of Natural History. (Lantern; 15 min.)

The mating responses of male rats to receptive females were tested before and after castration, unilateral removal of the cerebral cortex, unilateral hemidecortication plus castration, and complete decortication with and without castration. Males that failed to copulate after operation were injected with testosterone propionate until copulation returned or until 20.0 mg. of the hormone had been administered.

Ninety days after castration only the most incomplete mating responses survived, but the injection of small amounts of androgen revived the copulatory reaction and ejaculation returned after somewhat larger doses had been administered. Unilateral decortication eliminated mating in some males and left the behavior undisturbed in others. Noncopulating hemidecorticates could be reactivated sexually by hormone therapy, but the amounts of androgen needed were appreciably larger than those which had proven effective in the case of castrated males.

Complete decortication with or without castration permanently eliminated copulatory behavior. Some decorticated males exhibited an increased responsiveness to the estrous female when testosterone propionate was injected, but copulation never occurred despite administration of 20.0 mg. of the hormone.

26. COMPARISON OF PATTERNS OF CYCLIC ACTIVITY OF WOMEN AND THE FEMALE ALBINO RAT. Edmond J. Farris, The Wistar Institute of Anatomy and Biology. (Lantern; 15 min.)

Experiments based on walking activity of adult women and running activity of adult female albino rats show there are definite patterns of cyclic activity.

The walking activity of fifteen women, nine married and six unmarried, was measured for one to fourteen months. Three activity peaks were usually evident during the 45 menstrual cycles that averaged 29 days in length, as follows:

A mid-interval activity peak on cycle day 14, with an average walking distance of ten miles; a menstrual activity peak on cycle day 4, with an average walking distance of 9.7 miles; a late cycle activity peak on day 24, with an average walking distance of 9.8 miles. The average daily walking distance was 6.5 miles per cycle.

The running activity of over sixty female rats was measured from weaning to senescence. The adult female rats exhibited regularly marked increase in running every fourth or fifth day, averaging 23,200 revolutions in comparison to 11,700 revolutions for 24 hours during diestrum. Estrus is evidenced by increased running activity which begins at the onset. Other signs of heat are easily observed on days of greatest activity.

Both women and adult female rats exhibit a definite pattern of cyclic activity, hormonal in reaction. The activity is greatest in women usually at about mid-interval, the generally accepted time of ovulation. It has been observed in the rat that the peak of running activity is associated definitely with the processes of reproduction.

27. THE VAGINAL SMEAR OF THE RAT STUDIED WITH THE AID OF SHORR'S MODIFICATION OF PAPANICOLAOU'S STAIN. Carl G. Hartman and students, University of Illinois. (Lantern; 15 min.)

The following cell types are distinguished, appearing more or less in the order named (colors according to the Shorr stain): (1) large blue cells of proestrium, nuclei dull, finely granular; (2) scales only (brilliant red-orange); (3) ''Shorr'' cells, large blue cells, nuclei vesicular (chromatin condensed in large granules), present in all mammals studied especially in the ungulates, in the cow the predominant cell for some days following estrus; (4) cells similar to preceding, with basophilic granules in the ample cytoplasm (from ''granular layer'' of Long and Evans); (5) leucocytes (first shower) from vaginal wall, which may not appear until 24 hours or more after estrus; (6) on third day leucocytes (of cervical origin) entangled in cervical mucus; (7) mucous cells (blue or often red) in variable proportion, sometimes absent; (8) medium sized epithelial cells (usually purple) containing one or more disintegrating leucocytes (acquired by cell before desquamation); (9) more or less degenerating ''deep'' cells, usually blue or green, nuclei pycnotic; (10) medium sized cells with dense red staining cytoplasm (not to be confused with cornified stage), often with refractile granules.

The method has only theoretical value, for example, to study the physiology of leucocyte migration, the contribution of the cervix to the vaginal smear and the cytochemistry of so-called cornification. (To be illustrated with Kodachrome slides).

28. EFFECTS UPON THE THYMUS OF PROLONGED MASSIVE INJECTIONS OF ESTROGENS IN ADULT FEMALE RATS. James C. Plagge, University of Illinois College of Medicine. (Lantern; 10 min.)

In the thymus of adult female rats large epithelial cysts develop after treatment with estradiol dipropionate for four months (0.1 or 0.2 mg. per week). The cells lining the lumina of the cysts vary in size and shape. There are occasional areas of well organized epithelium, composed of cuboidal or columnar cells, but in general the cells tend to be large and irregular in shape. The walls of the cysts vary from one to several cells in thickness. The lumina are filled with a secretion, often containing swollen and degenerating cells. The cysts are extensively inter-connected, and they end blindly, surrounded either by the parenchyma or the connective tissue of the thymus.

In spite of the presence of these hyperplastic epithelial growths, the gross weight of the thymus is reduced by 50 per cent or more in comparison with uninjected or sesame oil injected controls. The atrophy is apparent in both the cortex and medulla as a thinning out of thymic lymphocytes. The parenchyma is replaced by fibrous connective tissue, adipose tissue and the epithelial structures described above. Mast cells, normally present in the connective tissue of the thymus, appear to be relatively more numerous in the injected animals.

29. PITUITARY GLAND ACTIVITY AS INFLUENCED BY VITAMIN E. Earl H. Herrick, Kansas State College. (Lantern; 10 min.)

Male chickens fed a diet deficient in vitamin E became sterile from atrophy of the testes. Birds fed the same diet but with vitamin E added, retained normal development and activity of the testes. Pituitary glands from birds fed the E-deficient diet contained a larger number of degenerating basophilic cells than from those with the E added to the feed. ''Castrate cells'' were not found in pituitary glands of E-deficient birds even when the testes were in an advanced stage of degeneration.

Assays of fowl pituitary glands were made in which a gland suspension was injected into immature female mice. The degree of stimulation of vaginal epithelium in the mice was taken as the index of gonadotropic activity of the pituitary glands. Pituitary glands from birds receiving vitamin E, consistently showed greater gonadotropic activity than those from birds in which there was a deficiency of vitamin E in the diet.

30. THE GROWTH AND GONADOTROPIC ACTIVITY OF THE ANTERIOR PITUITARY OF THE COCKEREL. W. R. Breneman, Indiana University. (Lantern; 15 min.)

Pituitary glands of cockerels from hatching to 90 days of age were collected, weighed and assayed for gonadotropic activity. The growth curve rises very sharply up to 30 days of age, after which it plateaus until the 50th day, at which time it again rises abruptly. The weight of the glands expressed as a percentage of body weight is at a maximum at 10 days, after which it decreases sharply and tends to plateau after the 30th day. The acetone dried weight of the glands does not change greatly during the 90 days — the dried weight ranges from 13% to 18% during this interval.

The mouse uterus responded well to chick pituitary injection bu the responses to various dosages were not as critical as those which were observed when baby chicks were used. The potency of the pituitaries in terms of ''Chick Units'' (amount of pituitary necessary to produce a 35% increase in testis weights) increases slightly up to 25 days of age, after which the potency increases greatly. At 90 days the pituitaries have the equivalent of 1 Chick Unit per milligram of gland. The observations agree with the previously described cytological accounts that the pituitary becomes active during the interval between the 10th and 25th day and correlate well with the growth of the gonads. Approximately 1000 pituitaries and 600 animals were used for assays.

31. TIME AND QUANTITY RELATIONSHIPS IN HORMONAL SEX REVERSAL OF RANA CLAMITANS LARVAE. Beatrice Mintz, The State University of Iowa. (Introduced by Emil Witschi.) (Lantern; 8 min.)

Intraperitoneal injections of oil solutions of testosterone propionate (Perandren, Ciba) administered to large female larvae of Rana clamitans with well-developed ovaries have previously been shown to produce a reversal of sex to a condition resembling the typical male. Further studies indicate that complete sex reversal is obtained in 95 days with a total of 4 mg. (at .25 mg./wk.), in 123 days with a total of .9 mg. (at .05 mg./wk.), and in 144 days with a total of .525 mg. (at .025 mg./wk.). When the .25 mg. dose was administered alternately weekly and biweekly, sex reversal occurred in 95 days, though the total amount of hormone used was reduced to only 2 mg. This suggests a greater economy in biweekly injections. It also appears that the minimum time for sex reversal is not much below 95 days. In female as well as male larvae receiving testosterone propionate the mesonephric duct was not responsive to the male hormone; some cases showed a slight stimulation of the duct just before metamorphosis. In one metamorphosed male this stimulation proceeded to the extent of formation of small seminal vesicles (not present in controls) on the lower portions of the vasa deferentia. Formation of a small oviduct at metamorphosis was not suppressed in either males or females. Addition of gonadotropins (beef pituitary, pregnant mare serum, sheep pituitary extract), for concentrations and periods used, had no influence on degree or rate of change in animals receiving sex hormone.

Endocrinology and General Physiology (Sect. A)

40. AN ORGANIZER OF ENVIRONMENTAL ORIGIN, FOR THE SECONDARY SEXUAL ORGAN SYSTEM OF DROSOPHILA MELANOGASTER. John W. Gowen, Iowa State College. (Lantern; 15 min.)

The condition of no secondary sexual organ system in either males or females appeared simultaneously in several of our unrelated strains of Drosophila. The highest percentage in any one mating was 12%, the lowest, none. In the male only the testes remain; no trace of the paragonia, vas deferens, ejaculatory duct, penis, ejaculatory sac, clasper plates, etc. remain. In the female, the oviducts, azygos oviduct, parovaria, spermathecae, ventral receptacle, uterus and vagina are missing; the ovary alone remains. The testes are ovoid and take on yellow color in the presence of the wild type gene. In 2 specimens, for one testis each, a tube of about the length of the testis and yellow in color was pushed out of one end as though a vas efferens was in the making. The ovaries may develop medium sized eggs. As tests show that neither males nor females develop the characteristic courtship pattern of this species we may conclude that the physical basis of the sexual urge is found in the secondary sexual system voided through the loss of the organizer.

41. THE INFLUENCE OF THE MALE CICHLID FISH, TILAPIA MACROCEPHALA ON THE SPAWNING FREQUENCY OF THE FEMALE.

Lester R. Aronson, American Museum of Natural History. (Introduced by Charles M. Breder, Jr.) (Lantern; 15 min.)

Pairs of African mouth breeders were placed in the following six conditions: (1) male and female together in an aquarium (controls); (2) male and female in same aquarium separated by a glass grating; (3) male and female in same aquarium separated by a transparent partition; (4) male and female in same aquarium separated by an opaque partition; (5) male and female in separate aquaria with transparent adjacent walls; (6) male and female in separate aquaria, the adjacent walls being opaque. The dates of all spawnings of the females were recorded during a period of one year.

Compared with the controls, there was a small but significant increase in the frequency of spawnings of the pairs separated by gratings. The egg-laying frequency of females separated from males by transparent partitions, and those in separate tanks with transparent adjacent walls did not differ significantly from the controls.

Pairs separated by opaque partitions or in adjacent tanks with opaque walls, spawned much less frequently than the controls. This reduced frequency was accounted for by markedly increased intervals between spawnings. In these visually isolated females there was no indication that the frequency of spawning decreased with the length of isolation time.

It appears that there is an inherent spawning rate characteristic of the isolated female which is markedly increased by the sight of a male. Possible interpretations of the increased number of ovipositions of the pairs separated by gratings, and the significance of the above findings in relation to the ovulatory cycles of vertebrates will be discussed.

42. THE ROLE OF THE CORPORA ALLATA IN THE DEVELOPMENT OF LEUCOPHAEA MADERAE (ORTHOPTERA).

Berta Scharrer, Department of Anatomy, Western Reserve University. (Lantern; 15 min.)

Allatectomy was performed at various stages of development in Leucophaea maderae (Panchlorinae, Orthoptera), an insect which on the average has eight nymphal instars. As was to be expected from work in other species (Wigglesworth, Pflugfelder, Pfeiffer) extirpation of the corpora allata in the 8th instar, shortly after the last nymphal molt, had no visible effect on development. Allatectomy at stages earlier than the last instar (over 50 cases), however, caused an abbreviation of development that resulted in animals with more or less adult characters (''adultoids''). Thus in nymphs operated during the 7th stage the following nymphal molt was suppressed, and the animals emerged as adultoids resembling normal adults except for their smaller size and comparatively shorter wings. If 6th or 5th instar nymphs were allatectomized successfully the next molt produced ''preadultoid'' stages which did not reach a high degree of adultoid differentiation, but were distinctly different from normal nymphs of comparable age. These forms underwent only one additional molt at which they emerged as adultoids. The completeness of the operation was checked in serial sections through the heads of the animals. Whenever ordinary molts had continued to occur after the operation the extirpation was found incomplete. On the other hand in all cases of total removal of the corpora allata adultoids had resulted.

43. RETINAL EXTRACTS AND GROWTH IN MALE RATS. Ludvig G. Browman, Montana State University. (15 min.)

Twenty normal and 20 blind male rats which were autopsied on day 100 showed the following differences (see also Browman, '40): body, seminal vesicle, and pituitary weights were significantly less in blind animals; no significant differences were found in adrenal and liver weights; the testis weights averaged less, and the thymus weights averaged heavier than those of normal males but not significantly so.

Various crude extracts of the retina of light-adapted beef eyes were prepared in order to determine whether some principle was elaborated in the eye of normal intact mammals which when injected into bilateral optic enucleated animals would cause them to have body and organ weights like those of normal animals. These preparations were injected into males of an inbred strain of rats blinded on the day of birth.

The injection of preparations of ether extracts, and of bile extracts of beef retinas did not cause blind animals, at least ten rats in each series, to differ significantly from uninjected blind controls. Extracts of desiccated posterior lobe of the pituitary and Beta carotene solutions likewise had no beneficial effect.

The injection of saline extracts of beef retina equivalent to 3 rat retinas by weight per day, beginning at 2 weeks of age and continuing for a period of two months, did cause body and organ weights of blind males to be essentially like those of normal males. There was no significant difference between the normal and saline series in any weight category used.

44. INFLUENCE OF THIOUREA ON ORGAN WEIGHTS AND PLASMA PROTEINS OF THE RAT.[1] James H. Leathem, Rutgers University. (Lantern; 15 min.)

Adult male rats fed 1 percent thiourea in the stock diet lost 42 grams while the controls gained 15 grams in body weight over a 20 day period. Only a slight reduction in food intake occurred. While the anticipated increase in thyroid gland weight was observed, no weight changes were recorded for the pituitary, testes, spleen, kidneys or liver. A slight decrease in adrenal and ventral prostate weight and a marked decrease in seminal vesicle weight was recorded. Assay of the pituitary for gonadotropic hormone revealed a greater potency in the glands from thiourea fed rats.

A mild anemia and/or leucopenia was observed in some cases.

Blood analyses revealed an increase in non-protein nitrogen, total plasma protein and plasma globulin with no change in plasma albumin concentration. Plasma globulin level increased from 2.53 mg. percent in the controls to 3.10 mg. percent in the thiourea fed rats. The increase in the plasma globulin level in the absence of a change in plasma albumin concentration simulated the serum protein changes observed after thyroidectomy.

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[1] Publication of the Bureau of Biological Research.

45. INVOLUTION OF THE THYMUS IN YOUNG RATS WITH A TRANSPLANTED RETICULUM CELL SARCOMA. Eleanor H. Yeakel and Edmond J. Farris, The Wistar Institute of Anatomy and Biology. (Lantern; 15 min.)

A reticulum cell sarcoma, which arose spontaneously in several rats of the Wistar colony devoted to studies of aging, was found to be transferable to young animals. Intraperitoneal inoculation of small pieces of the tumor was followed by growth of the sarcoma in the abdominal cavity and metastasis to the mediastinal lymph nodes adjacent to the thymus, but not to the thymus itself.

In rats with spontaneous tumors, normal age involution of the thymus had taken place. In the young hosts, marked reduction in size of the thymus accompanied the rapid growth and spread of the tumor. Microscopically, the appearance of the thymus varied from that of normal tissue to one of accidental involution (extreme loss of thymocytes from the cortex, and obliteration of the corticomedullary boundary). After implantation of the sarcoma, no increase was noted in the number of lymphoid cells of the blood, although malignant cells were present in the circulation.

Young rats in our laboratory, engrafted with other kinds of tumors, confined to the abdominal cavity, have not exhibited the same degree of thymic regression found in those with the reticulum cell sarcoma. It would appear that the presence of the tumor in the lymph nodes contiguous to the thymus was responsible chiefly for the involution.

46. COLOR CHANGES IN REGENERATED TAILS OF ANOLIS CAROLINENSIS. Francis H. Wilson, Tulane University. (Lantern; 12 min.)

The American chameleon looses its tail at regular breaking points indicated by the scale pattern and by special constrictions in the body of the centrum. The regenerated tail is brown, lacking the ability to turn green, indicating that the oil droplet filter layer is not quickly regenerated. That this layer is finally regained is shown by the fact that regenerated tails eventually regain the ability to change from brown to green and vice versa.

47. MICROBIOLOGICAL ASSAY OF NICOTINIC ACID SYNTHESIZED BY CHILOMONAS PARAMECIUM. E. L. Powers and P. S. Stokely, University of Notre Dame. (Introduced by Rainer Zangerl.) (Lantern; 12 min.)

Pure cultures of Chilomonas paramecium were grown in the usual acetate-ammonium medium (thiamin and $FeCl_3$ added) for 48 hrs., centrifuged, dried under vacuum at 60°C. for 30 minutes, and finally put over P_2O_5 for 12 hrs. Assays of extracts of the dried cells gained by digesting with takadiastase, autoclaving in water and in HCl did not differ significantly when measured by the Snell-Wright microbiological method. All results were significantly lower than published results based on chemical assays. Use of the Krehl et al. modification of the microbiological method yielded still lower results. When compared with the amount of diphosphopyridine nucleotide in Chilomonas reported by Hutchens, the results indicate that nicotinic acid occurs in this organism only as a part of the cozymase molecule.

48. BIOASSAY OF ULTRAVIOLET TREATED HOG SAUSAGE. Edgar P. Jones and Joshua Stampfer, University of Akron. (Lantern; 10 min.)

Seven groups, each consisting of four or more ''vitamin-sized'' rats were used. One group was retained as a control. The remaining six groups became mildly rachitic when placed on the Steenbock-Black diet for a six week period. Their condition was established by sacrificing some of the animals, and examining the epiphysial lines.

Treated meat was now incorporated into the diets of certain of the experimental groups. For comparison, cod liver oil was furnished to one group. The six experimental groups (now rachitic) were fed as follows: A, normal and untreated sausage; B, Steenbock-Black diet (control); C. Steenbock-Black diet plus 25 gm. cod liver oil; D, mercury-quartz ultraviolet, 10 cm. distance, ½ minute exposure; E, same, 5 cm., 1½ min.; F, carbon arc ultraviolet, 30 cm. 1½ minute exposure.

The above diets were continued for six days after which all of the animals were sacrificed. The calcifying effects of the respective diets were determined by the ''line'' test of Shipley, as observed in the respective femurs. The ''indices of recovery'' for the six groups (A, untreated sausage, and B, control) were as follows: A, 0.75; B, 0.50; C, 2.50; D, 2.37; E, 2.50; F, 3.75. In this scale, 4.00 would indicate complete recalcification of all of the animals. Most of the F group had been calcium fortified beyond the normal in the six day period, demonstrating that the carbon arc treated sausage was strongly antirachitic in its action.

General Physiology (Sect. A)

49. HEMODYNAMIC AND RESPIRATORY EFFECTS OF CROTONIC ALDEHYDE IN DOGS.[1] Theodore Koppanyi, Department of Pharmacology and Materia Medica, School of Medicine, Georgetown University. (Lantern; 7 min.)

It has been suggested that allyl and crotonic aldehydes occur in various garlic extracts. Allyl aldehyde was since identified as a substance that produces fall of blood pressure to shock levels. It was deemed imperative to investigate the pharmacological action of crotonic aldehyde.

Crotonaldehyde was injected intravenously in doses of 10 mg. per kg. in 10 percent saline. The first injection of this aldehyde always produces a considerable fall of blood pressure, the second a fall followed by a slight rise, the third injection a slight fall followed by a considerable rise, and subsequent injections of the same dose produce pressor effects from 50 to 100 mm. of Hg. The depressor effects are not prevented by atropinization. The injections may be spaced 5 or 10 minutes apart. It is difficult to determine whether cocaine enhances the crotonaldehyde pressor effects because usually each injection produces a higher rise than the previous one.

Crotonaldehyde pressor effects are not diminished or abolished following the removal of the adrenals. Paralysis of the sympathetic ganglia by nicotine, however, diminishes and abolishes crotonaldehyde pressor effects.

Crotonaldehyde in the doses employed proved to be a very effective respiratory stimulant. Here again each dose produces a greater respiratory stimulation and of longer duration. The effect of the fifth or the sixth dose may last for an hour. The respiratory stimulation by crotonaldehyde is diminished following the removal of the carotid bodies and almost completely abolished following subsequent section of the vagi above the ganglia nodosa. Crotonaldehyde also has typical sympathetic stimulant effects on the eye and other organs. Anesthetized animals often show partial awakening following crotonaldehyde administration.

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[1] This research was supported by a grant of the Van Patten Pharmaceutical Co., Chicago, Illinois.

50. THE EFFECT OF PROPYL ALDEHYDE IN DOGS Theodore Koppanyi, Department of Pharmacology and Materia Medica, School of Medicine, Georgetown University. (Lantern; 8 min.)

Propyl aldehyde, a water-soluble liquid with a low boiling point (48°C.) has a marked pressor effect when given by the intravenous route except that it does not produce an initial vasodepressor effect like cortonaldehyde. It stimulates respiration although this action is feebler than that of crotonaldehyde. The mechanism of its respiratory and circulatory stimulating action is similar to that of crotonaldehyde. Due to its low boiling point, propyl aldehyde in concentrated form or in various solvents may be administered by inhalation. Inhalation of this aldehyde in anesthetized animals produces prompt vasopressor effects (up to 100 mm. of Hg.) and stimulation of respiration.

Propyl aldehyde does not stimulate the central nervous system like crotonaldehyde, on the contrary, it is a central depressant and synergizes with the narcotic action of aliphatic compounds.

51. THE INFLUENCE OF GLYCOTROPIC SUBSTANCES ON SURVIVAL OF THE PRIMITIVE RESPIRATORY CENTER OF THE ISOLATED RAT HEAD. Wm. A. Hiestand and Robert D. Tschirgi, Purdue University. (Lantern; 15 min.)

The decapitated rat head undergoes periods of gasping which indicate the survival of the ischemic respiratory center. Glycotropic substances affecting survival time, duration and number of gasps of the decapitated head are adrenaline, insulin, iodoacetic acid, anterior and posterior pituitary extracts, and ephedrine. Starvation modifies the results of these substances as less glucose becomes available. An additional series of gasps appears after adrenaline injection. The delayed period of gasps is entirely abolished in starved animals treated previously with insulin or iodoacetic acid indicating the anaerobic nature of this series of gasps. Aqueous extracts of anterior or pituitary gland greatly prolong the survival time showing effects quantitatively similar. Survival time is increased by adrenaline, anterior or posterior pituitary, but shortened by ephedrine, insulin, and iodoacetic acid.

52. THE INFLUENCE OF CERTAIN AROMATIC AND ALIPHATIC SYMPATHOMIMETIC AMINES ON RESPIRATORY CENTER SURVIVAL. Robert D. Tschirgi and Wm. A. Hiestand, Purdue University. (Lantern; 15 min.)

The effects of certain aliphatic and aromatic amines on survival time and number of gasps of the ischemic (decapitated) rat's head in 170 young rats (avg. wt. of 45 gm.) were determined. The aliphatic amines in general reduce the number of gasps and total survival time of the decapitated head. Those aromatic amines causing hyperglycemia prolong survival time by increasing the interval between successive gasps as well as by increasing the total number of gasps. Those aromatic amines increasing the frequency of gasping in general shorten the total survival time even though they may also increase the total number of gasps. This is due to the fact that the intergasp period is reduced. The latter group are those which are known to increase the sensitivity of the respiratory center.

53. PHYSIOLOGICAL CONDITIONS AFFECTING THE ELECTRICAL ACTIVITY OF THE BRAIN. T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia. (Lantern; 5 min.)

The so-called ''brain waves'' appear to be merely signals that tell us only about the way in which information is sent into the brain but not about the way in which the brain reacts to it (cf. Adrian, Science 99: 353, 1944). Moreover, purely somatic conditions have a pronounced effect on the electroencephalogram. The appearance of slow, pathological or delta waves in normal subjects is produced by deep breathing when the skin temperature of the fingers falls, the pulse rises and the blood sugar is not over 100 mg. % (determined by the micro method at finger tip). Thus two minutes of deep breathing in a person with a blood sugar of 90 and an increase in pulse rate from 70 to 108 changed the normal frequency from 9 to 4 per second and increased the voltage from 35 to 200 microvolts. In another normal person with blood sugar of 160, 5 minute of deep breathing was associated with a fall in pulse rate of 72 to 66 and the normal frequency of 10 per second actually increased to 18 per second with a voltage drop from 40 to 10 microvolts. The slow waves may result from the destruction of acetylcholine by the hydroxyl ions during acapnia. Also the increased pulse and fall in skin temperature (sometimes below room temperature) indicates vasoconstriction, and the resulting cerebral ischemia reduces the glucose which Quastel has shown is essential for synthesis of acetylcholine by brain tissue.

54. MODELS OF THE ACTION CURRENT IN CHOLINERGIC AND ADRENERGIC NERVES. R. Beutner and T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia. (Lantern; 5 min.)

Acetylcholine produces a negative electrical potential at the phase boundary between physiological saline and oil. This potential may be an essential part of the action current in parasympathetic and in medullated motor nerves. Moreover, acetylcholine has been demonstrated in sensory nerves by Lissak (Pfluger's Arch. 244: 120, 1940).

We have found that although acetylcholine will establish a potential on a wide variety of oils (nitrobenzene, guaiacol, cresol) no potential is observed on the triglycerides triacetin and tributyrin. (Owing to the low conductivity of tributyrin a mixture of one third part triacetin was used.) In contrast to the inertness of the acetylcholine on these oils, a representative sympathetic drug, benzedrine, was found to set up a sizable potential on triacetin. We infer that the differentiation between cholinergic and adrenergic nerves is determined by the type of lipoid in the plasma membrane. Acetylcholine and sympathin will not be expected to give potentials on the oil layer of all cells in the body. Thus in our model certain oils like toluidine do not produce phase boundary potentials with either epinephrine or acetylcholine.

The significance of the choline esterase for nerve potentials is obscure. Nachmannsohn's interesting investigations on this enzyme have failed to prove the presence of the mediator or explain the origin of the potential. As Loewi has pointed out (J. Pharmacol. 81: 67, 1944) the propagation of the impulse in eserinized nerve cannot be reconciled with Nachmannsohn's esterase theory.

55. The rate of healing of skin abrasions indicated by the positive wound potential. T. Cunliffe Barnes, Hahnemann Medical College of Philadelphia. (Lantern; 5 min.)

Over eighty years ago, DuBois Reymond (Researches on Animal Electricity, 1860, p. 268) demonstrated that skin wounds are electropositive (confirmed by Burr). In the present experiments the tips of four fingers of the left hand are sterilized and excoriated with sterile sand-paper until bleeding. The potentials are measured with a Micromax potentiometer with the injured left finger and the intact right finger in cups of saline. The wound potential was always positive (15 to 50 millivolts). The normal potentials before excoriation were: an average of 0.86 ± 0.13 mv. positive on right hand in 50 right-handed males (74% positive on right) and an average of 0.01 ± 0.18 mv. positive on right in 20 left-handed males (45% of these left-handed persons were positive on right).

Two fingers are treated with bio-dyne ointment (1.0% live yeast derivative, 3.0% liver oil in mineral jelly base). Two fingers are used as controls treated with the mineral jelly base. In a series of 100 of those experimental lesions two thirds lost the positive injury potential sooner than the controls, indicating the presence of trephones in the tissue extract accelerating epithelization of the wound. One gram of bio-dyne in 200 cc. of 0.9% NaCl set up a phase boundary potential of 10 mv. positive on nitrobenzene measured in an oil cell (see Beutner and Barnes, Biodynamica 4: 47, 1942). Thus the diminution of the positive injury potential indicates healing and not a direct electrical effect of the tissue extract.

56. Correlation of electrical and chemical changes in the dark-adapted insect eye. Verner John Wulff and Theodore Louis Jahn, The State University of Iowa. (Lantern; 15 min.)

The relationship between intensity of stimulating light and the magnitude of the electrical change in the eye was determined for the dark-adapted compound eyes of normal and deganglionated grasshoppers and two species of moths. Relationships between the concentration of photoproducts and the stimulating intensity were obtained from experiments of Hecht on the bleaching of visual purple solutions in vitro and from a theoretical equation (Hecht) describing the net rate of formation of photoproducts as a function of intensity in a reversible system. These relationships (EMF, concentration of photoproducts in an irreversible system, and theoretical concentration of photoproducts, all as a function of intensity) yielded sigmoid curves when either EMF or concentration of photoproducts was plotted against the logarithm of the intensity. It is concluded that the magnitude of the retinal action potential of the dark-adapted eye is a linear function of the concentration of photoproducts.

The linear dependence of the retinal action potential magnitude upon concentration of the photoproducts has now been demonstrated to exist in (1) the dark-adapted photoreceptor as a function of intensity (present paper); (2) the light-adapted photoreceptor as a function of intensity (Wulff, '43); (3) the dark-adapting photoreceptor as a function of time (Peskins, '42); and (4) both the light- and dark-adapted photoreceptors as a function of temperature (Jahn and Wulff, '43).

57. The action of the gene a on the tryptophane metabolism of Ephestia kühniella. Ernst Caspari, Lafayette College, Easton, Pa. (Lantern; 15 min.)

The gene a in Ephestia causes a reduction in the amount of pigment in the eyes and other organs. This is due to a lack of kynurenin which in animals containing the wild type allele a^+ is formed by oxidation of tryptophane. Tryptophane determinations in $a^+ a^+$ and aa Ephestia showed, that the latter contained significantly more tryptophane than the former, the unoxidized tryptophane being stored. v Drosophila, also a kynurenin deficient mutation, has a tryptophane content identical with v^+. Tryptophane determinations in different fractions of $a^+ a^+$ and aa Ephestia indicated, that most of the stored tryptophane of aa moths is contained in the protein fractions. The amount of protein N is not increased. It must be concluded, that qualitatively different proteins exist in $a^+ a^+$ and aa Ephestia. Whether the action of the gene a consists primarily in the inhibition of the enzymatic oxidation of tryptophane to kynurenin, or in the synthesis of qualitatively different proteins making part of the tryptophane unavailable, cannot be decided.

58. A method of recording contraction by means of electronic differentiation.[1] Alexander Sandow, Washington Square College of Arts and Science, New York University. (Lantern; 5 min.)

This method involves obtaining the time derivative of the isometric contraction of muscle by connecting the output of a crystal (piezoelectric) pickup actuated by the muscle to a low (5000 ohm) resistance. The capacitance of the pickup crystal of about 0.001 μf in series with the resistance forms an R-C differentiating circuit, with the desired derivative voltage pulse appearing across the resistor. This pulse is passed through an amplifier having a time constant of 16 sec. and then viewed on a cathode-ray screen. Comparisons of the electronically obtained derivative of a twitch with that calculated from simultaneously recorded optical myograms show general agreement to within 3%. Measurements of each record include relative values for the derivatives at maximum rate of contraction, D_1, and at maximum rate of relaxation, D_2; and the instants at which occur: D_1, D_2, the peak of contraction, and the end of the twitch, represented, respectively, by t_1, t_2, t_p, and t_e. Photographic records include, along with the cathode-ray derivative deflection, optically registered initial and peak tensions of the muscle. The ease and precision with which the various rates of mechanical change can be recorded and the use that can be made of such records make this a particularly advantageous method of studying muscular contraction.

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[1] Supported by a grant from the Penrose Fund of the American Philosophical Society.

59. The effect of activity on the twitch of frog skeletal muscle.[1] Alexander Sandow (with the technical assistance of A. G. Karczmar), Washington Square College of Arts and Science, New York University. (Lantern; 10 min.)

Using the above method, studies have been made of the effect of activity on the mechanical aspects of the isometric twitch of frog sartorii at an initial tension of 3 gm. and a temperature of 25°C. For 1 to 2 min. immediately following a short tetanus (up to 5 sec. duration) D_1 increases by 5 to 10% of its value before the tetanus, D_2 increases by 25 to 50% (in some cases by as much as 100%), and t_1, t_2, t_p, and t_e all generally fall, but with quite irregular decrements. During the following recovery period of 30 min. these changes are reversed so that the behavior finally is similar to that obtained priod to the tetanus. In an activity period consisting of a prolonged series of twitches at 3 sec. intervals: it seems that D_1 first decreases, then increases, and then decreases again; D_2 first rises and then falls; and in general the various time intervals first fall and then rise. It is evident that the rate of relaxation is especially changeable by activity; thus the relaxation period includes highly labile reactions and this suggests that this period is an active phase of muscular activity. The general changes can be correlated with pH alterations under comparable conditions. This indicates that the modifications in the mechanical response are caused by the effect of the activity-induced pH changes, probably by affecting the rates of hydrolysis of the adenosine-phosphate compounds of muscle.

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[1] Supported by a grant from the Penrose Fund of the American Philosophical Society.

60. EFFECT OF HYDROGEN PEROXIDE ON THE RESISTANCE AND CAPACITANCE OF FROG SKIN. Gordon Marsh, The State University of Iowa. (Lantern; 15 min.)

Parallel resistance and capacitance of dorsal skins of Rana pipiens were determined by direct balance on an a. c. Wheatstone bridge with modified Wagner ground between .3 and 70 kilocycles. A single-stage audio amplifier fed into crystal head phones or, above 10 k.c., into a tuned diode rectifier circuit with a sensitive galvanometer. The skins were mounted in a continuous flow vessel containing platinized Pt electrodes. Contact could be made with calomel electrodes for measurement of skin P.D.

Impedance, parallel resistance, and capacitance underwent the usual decline with frequency to nearly constant values at 70 k.c. In flowing Ringer the low frequency values increased with time to extremes of 20% for resistance and 40% for capacity, falling to lower levels after 8–20 hours. The inherent P.D. of the skins simultaneously underwent as much as 50% increase and 80% decrease, the direction of change being independent of the a.c. characteristics. Peroxide-Ringer between 2×10^{-7}M and 8×10^{-4}M altered neither resistance nor capacitance, changes being of the character of those occurring in Ringer alone, even with 100% increase in P. D. Strong peroxide produced irreversible decrease in P.D. and a permanent fall of resistance and capacitance. It is concluded that dilute peroxide produces no change in ion permeability nor in the ''ion impermeable structure,'' and that the mechanism of the inherent P.D. and the peroxide effect is not differential ion distribution controlled by permeability relations. Graphical solution of the phase angle yielded values of around 80°.

61. HEAT ACTIVATION, INHIBITION, AND INJURY OF PROTYROSINASE AND TYROSINASE. Joseph Hall Bodine, Theodore Newton Tahmisian, and David Leal Hill, The State University of Iowa. (Lantern; 15 min.)

Protyrosinase extracts, obtained from the egg of the grasshopper Melanoplus differentialis, have been subjected to a series of temperatures ranging from 55° to 85°C. and their activation followed.

Temperatures from 55° to 70°C. produce maximum activation while exposures to higher temperatures result in injury to the tyrosinase thus produced. At 83°C. the enzyme is destroyed.

Tyrosinase, produced by different activators, although showing similar catalytic properties, varies to a great degree in its resistance to temperature. The order of susceptibility to temperature for the activators tested is: aerosol OT>urea>sodium dodecylsulfate>heat>sodium oleate.

Morphology and Protozoology (Sect. B)

62. CONTRIBUTION TO THE OSTEOLOGY OF THE POSTCRANIAL SKELETON OF THE AMPHISBAENIDAE. Rainer Zangerl, University of Notre Dame. (Lantern; 12 min.)

New and interesting features of the shoulder girdle and front extremity of Bipes biporus include a highly vestigial, bony clavicle, a sesamoid element, homonomous to the patella, for which the term ''patellula'' is suggested, and a phalageal formula of 3, 3, 3, 3, 3. The vestigial pelvis and rear extremity consists of a bony ilium, femur and tibia. Lymphapophyses and distally forked ribs in the cloacal region of the vertebral column and the absence of true haemapophyses are typical in amphisbaenids as in snakes. The vertebrae resemble those of the lizards. The study of the postcranial skeleton adds evidence to the opinion, arrived at through the study of the skull, that the amphisbaenids are neither lizards nor snakes.

63. Numerical and regional distribution of taste buds on the tongue of the opossum, with particular reference to those in the fungiform papillae. Rush Elliott, Ohio University and E. B. Morris Biological Farm. (15 min.)

A study of the numerical and regional distribution of taste buds on the dorsum of the tongue of the opossum, Didelphys Virginiana, with particular reference to those in the fungiform papillae, has been made. The ages covered from 9 days postnatal through 135 days, with series taken at approximately 10-day intervals from the 25- through the 95-day series, and at 20-day intervals thereafter. Buds first appear in the 16-day series and there is a gradual increase in number through the 115-day series, with a decrease after that age.

The dorsum of the tongue from its cranial tip to the circumvallate papillae may be divided into fourths in relation to distribution of buds, with the greatest number in the middle two-fourths in all series studied. Few buds are present in the cranial fourth preceding the 75-day series, with a marked increase thereafter, and few are present in the caudal fourth before the 45-day series when the foliate papillae appear in this region.

Histological mappings prepared to show the position of the fungiform papillae in which buds are located reveal four distinct patterns of distribution: the first including the 25- and 38-day series, the second the 45- and 56-day series, the third the 65- and 75-day series, and the fourth the remainder of the series studied.

64. The granular cells of the juxtaglomerular apparatus. F. W. Dunihue, Medical College, University of Vermont. (Lantern; 12 min.)

Reports on the occurrence of fuchsinophilic granular cells in the juxtaglomerular apparatus in different species of mammals are contradictory. This discrepancy seems to be the result of variations in the technical procedures used by different investigators; since the granules are clearly visible in unstained, fresh or formalin fixed frozen sections but not in stained, formalin or Zenker fixed paraffin sections.

After procedures which induce experimental hypertension in the rabbit, the granular cells are hypertrophied and hyperplastic. The granules of these cells are a pale yellow color in unstained, fresh or formalin fixed frozen sections. With appropriate technics these granules give a positive chromaffin and argentaffin reaction. These reactions argue against the interpretation of these cells as mastocytes or histiocytes, but provide no evidence for a specific type of function on the part of these cells.

Cells of the juxtaglomerular apparatus in the hypertensive rabbit contain mitochondrial rods and a Golgi apparatus. The quantity of mitochondria appears to be inversely proportional to the quantity of fuchsinophilic granules; but there is no evidence for a transformation of mitochondria to the granules.

Human kidneys, both surgical and post-mortem, contain variable numbers of juxtaglomerular granular cells which appear to be identical with those found in rabbit kidneys. There is, however, no apparent correlation between the number of granular cells present in the human kidney and the level of the blood pressure.

65. Phase-difference microscopy for transparent objects. A. H. Bennett, Research Division, Spencer Lens Company, Buffalo, N. Y. (Introduced by Morden G. Brown.) (Lantern; 15 min.)

Microscopic specimens frequently contain details which differ from their surrounding media only by slight differences in index of refraction. Because such details may absorb light in a negligible amount they are often invisible. Previous attempts to render such details visible by purely optical methods will be briefly described. One of these, the phase-difference method has been studied by us. Theoretical work, based on optical diffraction has been done as a basis for extending the phase-difference method and applying it to practical microscopy. Some of the applications will be presented in the following paper. Details of the theory and experimental apparatus are essentially in the fields of mathematics and physics and will be presented elsewhere.

66. PHASE-DIFFERENCE MICROSCOPY FOR LIVING UNSTAINED PROTOPLASM. Oscar W. Richards, Research Division, Spencer Lens Company, Buffalo, N. Y. (Lantern; 15 min.)

The transparent protoplasm within the cells of many living organisms is composed of regions that differ from each other, although often not different enough to be seen easily. Hitherto such regions were demonstrated by closing the condenser of the microscope to give a very narrow illuminating beam, which largely destroyed resolution with only slight gain in contrast; or else stains were used to provide visible differences. Most stains cannot be used with living material and limit observation to post-mortem study.

The different regions, or phases, in the protoplasm are often different from each other in their refractive indices, which differences change the phase relation of the light waves passing through them. The phase alterations of the light are not visible to the eye, but the insertion of proper phase changing plates into the microscope converts the phase changes of the light curves into visible intensity differences. In general the region of different refractive index may be made either dark or light with respect to their surroundings. Different plates with greater or less retarding or absorbing regions are required for the observation of different transparent materials. Making a region, or particle, darker facilitates measurement. Movement and small particles are more readily seen when made brighter than their surroundings. The resolution of the microscope appears not to be reduced so that intracellular content otherwise invisible may now be seen. Preliminary application in the microscopy of living, unstained cells and tissues will be discussed.

67. SEROLOGIC DIFFERENTIATION OF THE THREE SPECIES OF PARAMECIA IN THE AURELIA GROUP. James A. Harrison and Elizabeth H. Fowler, Temple University. (Introduced by Earl A. Dennis.) (Lantern; 12 min.)

More than 200 clones of paramecia of the aurelia group were subjected to identification with the serologic reaction of immobilization in pools of anti-paramecia rabbit sera. Each pool of serum was composed of several antisera selected in such a manner that they represented most of the antigenic types found in studies of smaller numbers of strains of each species. Most of the clones were identified morphologically in stained smear preparations. The majority of them reacted in only one pool of serum — the identifications thus made were in complete agreement with the morphologic findings. A few clones failed to react in any of the pools and a few gave reactions in two pools. The results indicated clearly that serologic differentiation of species in the aurelia group is feasible.

68. THE UTILIZATION OF AMINO ACIDS BY THE CILIATE TETRAHYMENA GELEII. George W. Kidder, Brown University. (Lantern; 15 min.)

The search for an adequate carbon and nitrogen source, of known chemical composition, which will support the growth of ''pure-culture'' ciliates has resulted in the following findings:

Indefinitely transplantable although low growth of Tetrahymena geleii (strain W) is obtained using a mixture of six amino acids supplemented with nitrogen-free extracts of alfalfa. The amino acids which were found to be indispensable for this ciliate are histidine, leucine, lycine, threonine, valine and tryptophane. Growth is markedly increased by the addition of arginine and is inhibited by the addition of glutamic acid or tyrocine. The inhibitory effects of glutamic acid and tyrocine can be counteracted by additions of other amino acids. Quantitative results indicate cumulative action of a number of the amino acids above the basic six for this strain. It has been possible to obtain growth with amino acid mixtures comparable to those resulting from the use of biuret negative casein or gelatin hyrolysates.

The addition of a separate source of carbon has little effect upon growth rate but does prolong population survival.

69. THE FOOD-VACUOLE IN THE PERITRICHA, WITH SPECIAL REFERENCE TO THE HYDROGEN-ION CONCENTRATION OF ITS CONTENT AND OF THE CYTOPLASM. S. O. Mast and W. J. Bowen, The Johns Hopkins University and the Marine Biological Laboratory. (Lantern; 15 min.)

The feeding apparatus consists of a ciliated tube (vestibulum and pharynx) and oesophageal fibers which extend from the pharynx nearly to the posterior end of the body. Attached to the pharynx there is a cone-shaped oesophageal sac, into which the pharyngeal cilia force fluid, particles and secreted gelatinous substance.

A portion of the enlarged sac is constricted off by the oesophageal fibers, to form the food-vacuoles.

Initiation of the constriction is dependent upon the size of the sac and the chemical composition of the fluid in it.

The food-vacuoles vary greatly in size.

Fluid passes from the sac into the cytoplasm, causing increase in the concentration of particles in it.

The food-vacuoles are forced rapidly to the posterior end of the body by the oesophageal fibers, then slowly on an irregular course by cyclosis.

After the rapid movement, the vacuole gradually rounds up, decreases greatly in size and becomes acid, then it rapidly increases in size and becomes nearly neutral.

The increase in acidity is largely due to metabolism in the feeding apparatus, impermeability of the vacuolar membrane to organic acids, and loss of water. The decrease in acidity is due to entrance of fluid from the cytoplasm.

The decrease in size is due to inward pressure of the stretched vacuolar membrane and excessive external osmotic concentration. The increase in size is due to excessive internal osmotic concentration.

The cytoplasm is approximately pH 7.4 and its osmotic concentration exceeds that of the exterior by 0.0125 M lactose.

Parasitology, General Evolution and Ecology (Sect. B)

32. GRANULAR STRUCTURES IN THE INCLUSION BODIES OF THE LYMPHOCYSTIS VIRUS DISEASE OF FISH. J. Richard Weissenberg, Department of Histology, Middlesex University School of Medicine. (Lantern; 15 min.)

Fibroblasts of fish invaded by the lymphocystis virus grow to gigantic dimensions and become the so-called lymphocystis cells. In their cytoplasm large inclusion bodies develop which stain like basic chromatin. In continuation of comparative studies on the lymphocystis cells of Pleuronectes, Acerina, Stizostedion, Lepomis, Aleutera and Fundulus the following results about the finer structure of the inclusions have been obtained. The basophil framework of the inclusions consists of membranelles which in optical sections appear as lattice-like structures. Within the membranelles very small basophil granules can be seen under the ordinary microscope with a magnifiaction of more than 1000 times. In the growing inclusions the granules rapidly increase in number. In more advanced stages groups of the granules become scattered through the cytoplasm while the membranelles disappear to a great extent. Some remnants of the membranelles, however, persist and regenerate to new inclusion bodies in which again granules become visible.

The groups of granules when scattered through the cytoplasm stain acidophilic. They can be distinguished from ordinary cytoplasmic granules by their resistance against acetic acid and by a characteristic staining with osmic acid by means of fixation after Kopsch or Sjövall. Probably these granules represent the stages of transmission of the virus to be compared with the elementary bodies observed in virus diseases of mammals and birds. The basophil framework of the inclusions can no longer be considered as a product of the host cell, as suggested by me in 1921, but apparently represents a developmental stage of the virus.

33. Studies on the life history of the oribatid mite Galumna sp., intermediate host of Moniezia expansa. Horace W. Stunkard, New York University. (15 min.)

Stunkard (1937, Science 86: 312) reported that the sheep tapeworm Moniezia expansa is transmitted by an oribatid mite, Galumna sp. Epidemiological studies had indicated that the intermediate host has a one year life cycle and that contaminated pastures are infective for approximately a year. The mites have been raised in the laboratory from egg to adult and the life cycle consists of: egg, larva, three nymphal instars, and adult. At constant temperature of 25°C. and relative humidity of approximately 82%, the time required for completion of the successive stages varied as follows: egg, 8–14 days; larva, 11–26 days; nymph I, 9–21 days; nymph II, 11–25 days; nymph III, 13–35 days. If an individual spends a longer time in one stage, it is likely to pass through the next stage more rapidly and vice versa. The total length of the developmental period, from oviposition to emergence of adult, varied from 65 to 94 days. Adults kept over winter in the laboratory and others that wintered out of doors and were collected in February and March began to lay eggs the 2nd week of May. All of these adult mites died during the next summer. Whether they can survive a second winter under natural conditions is doubtful. The latest date of recorded egg deposition is October 4th. The above data thus are in accord with epidemiological observations that the intermediate host of M. expansa has a one year life cycle.

34. Human evolution and education: The timing of specialization. Hans Elias, Middlesex University. (15 min.)

Anatomically, man is primitive. Our brain is now the most highly advanced brain among vertebrates. But also the Marsupialia were, during the Triassic, the most highly advanced vertebrates. Yet we consider them primitive today. If primitivity is a condition from which many kinds of specialization can start, the human brain is primitive. From this results our versatility. Versatility is the most important human characteristic. It is the basis of freedom.

Modern education, becoming more and more utilitarian tends to begin intellectual specialization at earlier and earlier ages. Thus many mental functions and phases of human activity are being suppressed. The specialty, because treated in isolation, is being mechanized, and its significance remains not understood. Versatility is being reduced. Man, trained to make a living only, becomes reduced to the state of an animal.

Human evolution has consisted in part in the enrichment of the mental life. The departmentalized high schools and the specialized college curricula are producing a mental polymorphism. The average individual no longer understands the whole of life. The individual is therewith being reduced to the status of an understrapper in the superorganism of society. If this development is allowed to continue, mankind will drag irreversibly into the condition of an ant colony. Homo sapiens will become Homo mechanicus.

In order to maintain human evolution as gradual rise of intelligence, elementary and secondary education must be broad and universal. Specialization must begin after an understanding of all phases of culture has been reached.

35. Speciation in the American Genus Mustela. E. R. Hall, University of Kansas. (Lantern; 15 min.)

The number of full species is reduced from 50 to 4; the number of subspecies is increased from 60 to 70. Two of the species prove to be circumboreal. Appraisal of relationships of species supports Matthew's theory of Climate and Evolution. Molt in the wild-animal shows a reversal of pattern in autumn and in spring. A secondary sexual difference exists in winter whitening. Many characters diagnostic of species and of subspecies appear to be acted upon by natural selection but certain characters appear to be independent of natural selection and, climate is judged to be the most potent factor in speciation of the American weasel of the genus Mustela.

36. HENS THAT ARE MEMBERS OF AS MANY AS FOUR FLOCKS MAY MAINTAIN A DIFFERENT SOCIAL STATUS IN EACH. Marjorie B. Douglis, Whitman Laboratory of Experimental Zoology, The University of Chicago. (Introduced by W. C. Allee.) (Lantern; 15 min.)

Since 1922, when Schjelderup-Ebbe reported that the social hierarchy of domestic fowl is based on peck right, there has been a growing study of this peck order in which the dominant bird pecks her subordinates without being pecked in return. There is much evidence that each hen individually recognizes each of her flockmates.

If two birds are moved from their home flock (A) into a new flock (B) and are then returned to A for half an hour daily, they are able to maintain a definite rank in each flock. After the new members have established their social rank in B they can be introduced into a third and then a fourth flock, and if returned to the other flocks for half an hour daily, can maintain status in each. Knowledge of their position in the peck order in the original flock does not enable the experimenter to predict the rank they will achieve as members of other flocks.

At present there are five hens that are members of only two flocks, one hen is a member of three flocks, and two hens are members of four flocks. A typical set of reactions is shown by these last mentioned that come in contact with a total of twenty-four others in the four flocks. They rank first and second respectively in one flock of six hens, second and third in a second flock composed of ten hens, sixth and seventh in a third flock of ten hens, and first and eighth in a fourth flock of eight hens. When moved from one flock to another, once their rank has been established, their acceptance of status in each flock is immediate and definite.

37. THE SOCIAL ORGANIZATION RESULTING FROM THE INTRODUCTION OF PAIRS OF YOUNG CHICKS TO A SMALL FLOCK OF CHICKENS AND PIGEONS. Howard H. Vogel, Jr., Wabash College. (Lantern; 12 min.)

Incubated chicks, two to seven weeks old, were introduced in pairs to a flock of chickens and pigeons kept in a small greenhouse. Trays, in a central feeding pen, were kept filled with mash. The flock was limited to twelve birds.

The older hens pecked each pair of chicks vigorously soon after their introduction. A peck-right was established with the older hens dominant over the younger birds.

Allelomimetic behavior (mutual imitation) is strong in chickens. The members of each pair remained close together in all their activities, and each pair formed one social group. The young birds soon associated the preesence of a dominant hen with pecking, and fled immediately. Thus the number of actual pecks decreased as the length of association increased.

The members of each pair of young chicks were sometimes of the same sex, sometimes heterosexual. There was no pecking, nor any fighting behavior, observed between members of any one group. Young chicks often joined with another slightly older pair. No fighting has been observed within this larger social unit.

A rooster, submissive as a chick to adult hens, became dominant with sexual maturity. The bird had been introduced together with a female chick that later died. The cock remained outside the various hens' social groups, except for sexual behavior. He rarely pecked young chicks.

Intra-group mutual feeding and grooming was observed. Distinct social groups, based on what may be termed group peck-right, were evident in all activities of the birds.

38. GROWTH CURVES AND CHANGES IN FORM OF THE TWO COLEOPTEROUS LARVAE (EPILACHNA CORRUPTA MULS.) AND (LAEMOPHOLEUS MINUTUS OLIV.). Nellie M. Payne, American Cyanamid Company. (Lantern; 15 min.)

Mexican bean beetle larvae (E. corrupta Muls.) grow differentially and, by means of this differential growth, change from a campodeiform to a near scarabeiform type. Proportional scale drawings show the change in per cent of the body, head, thorax and abdomen.

The lesser grain beetle (L. minutus Oliv.) also has a differential growth pattern, but the changes in form are not as striking. The appendages of the early stages are larger in proportion to the total body than in the later stages. As might be expected, the head is also proportionally larger in the earlier stages than in the later. There is no sudden change in dorsoventral growth and, therefore, no marked thickening as in the Mexican bean beetle.

39. NOMADISM IN THE SWARM-RAIDING ARMY ANTS AS AN INSTANCE OF ANIMAL MIGRATION. T. C. Schneirla, American Museum of Natural History, and New York University. (Introduced by William Etkin.) (Lantern; 15 min.)

For 53 days in the Panama rainy season a colony of the swarm-raiding doryline species Eciton burchelli remained under observation. The study began with (1) a period in which large daily raids were terminated by evening movement to a new bivouac site; next (2) there was a period in which raids were small and bivouac changes did not occur; then (3) a period of large raids and of nomadism; and finally (4) another period with small raids and no changes of bivouac. This record is supplemented by others of shorter duration, which indicate that E. burchelli has a predictable behavior cycle in which phases of maximal raiding and nomadism (''nomadic'' condition) occur regularly in alternation with phases of minimal activity and no colony removal (''statary'' condition). Paralleling the alternating conditions in colony behavior, there are changes in the condition of successive broods which appear fundamental for the understanding of the colony behavior pattern. Species differences in the time relations of the cyclic behavior changes appear to be of some significance. In view of the evident basis of the Eciton behavior pattern in colony reproductive functions, and the regularity of the general phases as well as of successive bivouac-change movements in a single nomadic phase, this behavior may be considered a valid instance of animal migration.

PAPERS PRESENTED BY DEMONSTRATION

Motion Pictures

73. ADDITIONAL OBSERVATIONS ON MATING BEHAVIOR OF THE SAGE GROUSE. John W. Scott, University of Wyoming. (Motion pictures in Kodachrome.)

In 1941, 1942, a unique, polygamous system of mating in sage grouse was described; characterized by morning and evening assemblies at which master cocks accomplished most of the mating. Dominance of master cock on a mating spot tends to break down, (a) as number of hens ready for mating increases beyond capacity of cock to serve, (b) as the master cock becomes surfeited with mating, (c) as the season advances. At peak of season, with very large assembly of hens, the sub-cock or guard cock occasionally has opportunity to mate with a hen near fringe of the group. After peak of season as master cock becomes surfeited, he may allow sub-cock or guard cocks to mate. However, as the season advances, the master cock mates less frequently, ignores hens ready for mating, frequently fights other cocks attempting to mate with waiting hens, with result that unsatisfied hens go away to mate with some outside cock, or wander off the area unmated. A primary mating spot is seldom used more than two years in succession, sometimes only one. Peak of the mating season varies with mean seasonal temperature. Earliest mating recorded was 58 minutes before sunrise, with meter reading less than one candle power. A record of 24 matings by master cock in one morning. A second instance of mating at evening assembly observed. Additional observations made on heteroclite cocks and hens.

74. THE HATCHING PROCESS IN THE BOBWHITE QUAIL. Howard H. Vogel, Jr. and J. P. Scott, Wabash College. (Motion pictures in Kodachrome.)

Motion pictures, 16 mm., kodachrome, were taken of the hatching of three chicks of the bobwhite quail, Colinus virginianus. A dozen eggs, secured from the Indiana State Department of Conservation, were placed in a small incubator at a temperature of 37.5°C. Water was placed in the incubator; the eggs were turned twice a day. Nine of these eggs hatched normally on the twenty-third day, one hatched with help, one was fully developed but dead before hatching, and one egg did not develop.

While being photographed the eggs were placed on an electric egg-warmer. Moisture was added from a medicine dropper to facilitate hatching. Time-lapse photography was used, one frame of film being exposed every thirty seconds.

Conclusions: 1. The egg shell is first cracked on the twenty-first or twenty-second day of incubation.

2. The hatching chick works hard during the process, heaving upward about seven or eight times a minute, alternating active periods of shell-cutting with periods of rest. Each heave is often accompanied by a cheep.

3. The ''egg-tooth'' of the bird's beak cuts a circular path around the egg, halfway between the equator and the blunt end.

4. The bird does not cut completely around the egg, but allows the smaller cap to open as a hinge.

5. The chicks require between one and two hours to hatch. Lack of moisture slows up the process.

6. Newly hatched chicks should be removed from incubators immediately after hatching as they may disturb developing eggs.

75. THE ANALYSIS OF PROSTASIA (SOCIAL CONTROL AND LEADERSHIP) IN A SMALL FLOCK OF SHEEP. J. P. Scott, Wabash College. (Motion pictures in Kodachrome.)

Prostasia, defined as any sort of social control whether stimulating or inhibiting, was observed in a small flock of sheep in connection with five combinations of social behavior, the behavior following the arrow being that of the subordinate animal: (a) allelomimetic→allelomimetic, (b) epimeletic→nursing, allelomimetic, (c) et-epimeletic→epimeletic, (d) sexual →sexual, (e) fighting→fighting, moving away, or inhibition. Of these, unequal prostasia involving allelomimetic behavior (mutual imitation) between mother and lamb (a) appeared to be the most important and may be analyzed as follows. The mother calls to the lamb (epimeletic behavior) which comes to her and nurses (b). The repetition of this pattern of behavior conditions the lamb to follow the mother, and the lamb generalizes this reaction so that it follows all older sheep. After weaning the response of following is no longer reinforced with a reward and tends to die out gradually in older sheep. This process is hastened in ewes after becoming mothers by their subordination to the behavior of the lambs (c), and in rams by separation from the ewes. Unequal sexual stimulation (d) results in a tendency for a ram to follow any ewe. Dominance, defined as prostasia based on fighting or force (e) appears to be relatively unimportant. The total result is that the oldest ewe leads the combined flock on most occasions (a). This analysis suggests a general type of approach to the solution of certain human problems of leadership.

General Demonstrations

76. DEMONSTRATION OF THE VAGINAL SMEAR CYCLE IN THE GROUND SQUIRREL. Geo. Finlay Simmons, The University of Chicago and Loyola University School of Medicine.

Slow changes in the vaginal smear of an annual-breeding wild rodent by means of a simple dry-smearing technique for permanent smears without fixation or mounting, but stained with hematoxylin and eosin. Anestrum occurs from July to January, with the shift to early proestrum during hibernation during January; full proestrum occurs in late March or early April, just before emergence from the winter burrow; early estrus is characterized by a new cell type, during April, ending with cornification of full estrus in late April or early May, when coitus occurs as the vagina begins to open. A characteristic vaginal plug is formed, persisting for some 24 hours, with sperm in the smear for 56 hours. Gestation, usually 28 days in May, shows weekly variations in the smear, which shows postpartum recovery during the lactation period in June and early July. The smear during parturition contains red-blood corpuscles. The estrous smear in the absence of the male proceeds to late estrus and persists in an irregular fashion for four to six weeks, then recedes through metestrum.

77. SEXUAL CYCLE OF THE MALE LONG-TAILED WEASEL. Philip L. Wright, Montana State University.

Data are available from 55 animals mostly from Montana. Forty-two of these were preserved in the field, and 13 were captive animals in which the cycle was observed. Young males which are born in April or May attain 85% of their adult size before September. The testes show no marked enlargement until the following March when growth to active condition starts. The testes reach maximal size in April and spermatogenesis continues until August. Adult males are probably capable of fertile coition from April until September, although most of the mating occurs in July and August. Young males are distinguishable from the adults by cranial characters and by body weight only through the fall, but throughout the winter by a difference in the size of the baculum. The testes start the spring growth at the onset of the molt from white to brown, and the fall molt to white starts only after the testes are regressed. This relation holds rigidly when the molt and testis cycle are experimentally modified. Since both the young and adult females breed during the summer while the young males are still immature, the adult males are polygynous. The inactive testes of the adults during the winter are larger than those of the yearlings during the same season. Unilateral cryptorchidism was observed once. The cycle is similar to that of the ferret and the European stoat.

78. MAMMARY GLANDS OF RATS FROM THE WISTAR INSTITUTE.[1] Virgene W. Kavanagh and Ralph P. Reece, New Jersey Agricultural Experiment Station.

Mammary glands of immature male and female rats consisted of thick-walled ducts and were indistinguishable histologically, though the female ducts were more extensive.

At maturity the male glands developed alveolar lobules, usually without lumina; and epithelial cells filled the ducts. In some old males, especially albinos, small patches of disintegrating epithelial cells and connective tissue remained among fat cells. In others, chiefly Grey Norways, ducts reopened, partially or completely; and lobular parenchyma secreted colloid or serous material. Several glands 700 and 900 days old had not regressed.

Glands from mature non-pregnant females consisted almost entirely of ducts. This condition persisted in some old rats, especially Grey Norways, with ducts intact or, more often, collapsed with sloughed epithelium. Most of the albinos 300 days old or older had cystic mammary glands in which some areas, at least, approximated the development at some stage of pregnancy. Connective tissue was superabundant, often hard, and fuchsinophilic. The ''milk'' was abnormally high in colloid drops, colostrum corpuscles, and corpora amylacea. A few of the oldest Grey Norway rats had similar glands.

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[1] This study of Wistar Institute rats is part of a program on ageing, organized by Dr. E. J. Farris of The Wistar Institute, with the support of the Samuel S. Fels Fund.

79. SOME FEATURES OF THE ANATOMY AND PHYSIOLOGY OF ANOLIS CAROLINENSIS. Francis H. Wilson, Tulane University.

Color changes in the blind-folded individuals with and without regenerated tails will be shown in living specimens. Parietal eyes, scale patterns indicative of breaking planes and modifications of caudal vertebrae for breaking will also be demonstrated.

80. THE GROWTH RATE OF TADPOLES RAISED IN VARIOUS DILUTIONS OF RINGER'S SOLUTION. William Etkin, American Museum of Natural History and College of the City of New York.

The following is a summary of the results attained in a series of investigations carried on by ''Honors'' students working under my direction. Tadpoles of Rana pipiens secured by induced ovulation were used with occasional confirmatory experiments on other native species.

Tadpoles can be raised in distilled water but their growth is poor. Even small quantities of Ringer's, as 1: 1000, greatly improve the rate of growth. Above 1: 50 R. growth approaches close to the optimum rate which comes in 1: 4 R. At this point the growth rate is about twice that in distilled water. Above 1: 4 R. the rate declines with increased concentration until in full Ringer's growth is even poorer than in distilled water. Kidney size is increased in distilled water as compared to 1: 4 R. Tadpoles show marked ability to retain chlorides after transfer from 1: 4 R. to distilled water. Considerable excess food (lettuce) in water nullifies deterrent effect of distilled water. Growth in distilled water is markedly improved if tadpoles are removed to 1 : 2 R. for one hour daily. The growth rate is not much affected by differences in pH encountered in the present experiments (range 5.2–8.4).

These results are interpreted as indicating that the principal factor inhibiting growth in distilled water is lack of salts rather than osmotic or direct toxic effect. In concentrations above 1: 4 R. the disturbance in water metabolism probably plays the most important role.

81. THE INTEGUMENT, COLORATION, AND COLOR CHANGE OF SOME ANURANS. Hans Elias, Middlesex Veterinary School.

The structure of warts and tubercles, the color change, the optical properties of certain pigments, and the movements of chromatophores in several anuran families will be demonstrated by means of pictures and under the microscope.

82. THE DEVELOPMENT OF MELANOMAS FROM MACROMELANOPHORES IN DIFFERENT BODY REGIONS UNDER GENETIC CONTROL. Myron Gordon, New York Zoological Society.

In Platoypoecilus maculatus five genes are known each of which produces its normal pattern by controlling the growth of morphologically similar cells, the macromelanophores. The genes differ, first, in the different regional patterns they produce and second, in the degree of tumor malignancy they produce in hybrids when mated to Xiphophorus hellerii. These two items are related for the most malignant melanoma is produced by that gene which produces the most irregular initial pattern.

Heretofore the specific genes reported as being involved in tumor production in hybrid fishes were the spotted, Sp, and the black-banded, N. The Sp produces an irregular spotted pattern involving all parts of the body; N produces black sides. Sp in Platypoecilus-Xiphophorus hybrids produce true melanomas which may appear in any part of the body surfaces; N in similar hybrids produce melanomas which usually appear only on the flanks. Thus the localization of the tumor is more predictable in N than in Sp fishes.

Tests were made of three additional genes for macromelanophore patterns which were found to exist in natural P. maculatus populations in Mexico. The spotted-belly gene, Sb, produces markings most intense on the mid-ventral area: while the spotted-dorsal gene, Sd, is just the opposite and marks the dorsal fin. The striped, Sr, gene produces several rows of macromelanophores on the flanks. In hybrids Sb produces mid-ventral, while Sd produced mid-dorsal tumors. Sr produces no tumors in F-1 but they appear on the flanks of backcross hybrids with Xiphophorus.

The order of intensity of melanoma malignancy produced by various genes is: Sp, Sb, N, Sd, Sr. The degree of malignancy as well as the region of the tumor depends primarily on the inherited pigmentation pattern.

83. A rapid method for demonstrating mammalian somatic mitoses. Helen Gay and Berwind Kaufmann, Industrial Hygiene Research Laboratory, National Institute of Health, and Department of Genetics, Carnegie Institution of Washington.

Mitoses occur abundantly in the lowermost epithelial layers of the corneas of various mammals. These dividing cells may be prepared for study by rapidly fixing and staining the entire cornea, and mouting it as a flat preparation. Our method, which was developed for a study of the effects of short-wave radiation on the mitoses of the corneal epithelium, involves fixing in a mixture of alcohol and glacial acetic acid, and staining in orcein. It has been used successfully on the corneas of rats, mice, rabbits, cats, dogs, and one monkey. The preparations obtained are adequate for making chromosome counts with a fair degree of accuracy, and for demonstrating details of chromosome organization.

84. Phase-difference microscopy of living unstained protoplasm. Oscar W. Richards, Research Division, Spencer Lens Company, Buffalo, N. Y.

The microscope described in the oral presentation will be used to demonstrate some of the advantages of phase difference microscopy.

PAPERS PRESENTED BY TITLE

Cellular Physiology

85. The survival of human spermatozoa in solutions of penicillin. Landrum B. Shettles, The Johns Hopkins Hospital.

The question has arisen as to whether penicillin is toxic for human spermatozoa or affects spermatogenesis. The human spermatozoon is an excellent cell against which to test toxicity in that in general it is markedly sensitive to various reagents. Accordingly penicillin was prepared in normal saline in concentrations ranging from 0.001 to 200,000 Oxford units per cc. Control solutions were made in the same way, except that they were inactivated by being boiled for one hour. Human spermatozoa of normal morphology, motility, and survival were placed in the solutions of varying strength and the controls, which were kept at both room and body temperatures and observed. There was no impairment of grade of motility or percentage of motile cells in the experimental as compared with the control solutions. Survival of human spermatozoa in their own seminal plasma, however, is better than in normal saline. Spermatozoa from patients receiving penicillin therapy are to be studied. The conclusion is that in vitro concentrations of penicillin well above the tissue concentration achieved by therapeutic doses, do not affect the survival or activity of human spermatozoa.

86. A selective lethal effect of penicillin on sarcoma cells growing with normal tissue in roller tube cultures. Ivor Cornman, The Wistar Institute of Anatomy and Biology.

Seven spindle cell sarcomas (6 rat and 1 mouse) grown in roller tube cultures along with cells from normal muscle of the same host strain were killed by concentrations of penicillin which did not kill the normal fibroblasts. Higher concentrations killed normal tissue as well, and lower concentrations damaged the malignant tissue without visibly affecting the normal cells. Of 261 muscle explants, 112 were not damaged, 92 showed incipient damage, and 57 showed marked damage; none were killed. Of 341 sarcoma explants, none were unaffected, 29 were slightly damaged, 208 were markedly damaged, and 104 were killed. A second mouse tumor did not show a definite susceptibility. In untreated tubes, the sarcomas grew better than the normal. Penicillin damage increased with increased dose, and the selective effect was independent of variations in the formula of the medium. This shows that some component of pharmaceutical penicillin has a selective lethal action upon sarcoma cells in vitro, but the identity of the component with the bacteriostatic factor has not been established.

87. The effects of potassium cyanide, potassium arsenite, and ethyl urethane on respiration in Pelomyxa carolinensis. D. M. Pace and W. H. Belda, University of Nebraska and St. Francis Seminary.

Pelomyxa carolinensis Wilson (Chaos chaos Schaeffer), a multinucleate rhizopod, is a favorable organism for cellular studies, especially respiration studies, because of its relatively large size and because it can easily be grown in the laboratory. In these experiments the rate of oxygen consumption was measured by means of a Barcroft-Warburg apparatus. In the tests with cyanide, Krebs' KOH-KCN absorption solutions were used in the inner well of the manometer flasks.

In 10^{-5} M KCN, respiration in Pelomyxa is inhibited by 63 percent. In higher concentrations (up to 10^{-2} M) only slightly greater inhibition occurs. In potassium arsenite the maximum inhibition is 35 percent and in 0.17 M ethyl urethane respiration is inhibited by 65 percent. Thus respiration in Pelomyxa appears to function chiefly through a cytochrome-cytochrome oxidase system, which itself is evidently dependent upon dehydrogenase, and partly through a mechanism involving glutathione. Evidence indicates that the function of the glutathione mechanism may be taken over by some other respiratory mechanism in the cell but the cytochrome-cytochrome oxidase system has no substitute.

88. The production of multipolar mitoses in normal somatic cells of embryonic chick tissue grown in vitro. E. Frances Stilwell, Woman's Medical College of Pennsylvania.

Multipolar mitoses and giant cells have been produced experimentally in normal somatic cells of embryonic heart tissue grown in vitro. Nine series of cultures (total 172) were made and examined microscopically for atypical division figures. It is signicant that multipolar division figures are present in one or more cultures of each series. They have been found in thirty-eight (38.7%) of the ninety-six cultures exhibiting a vigorous growth. Fourteen multipolar division figures are present among the 780 mitoses in the culture exhibiting the greatest number of multipolar cells.

The atypical division figures (triasters, tetrasters and aberrant forms) are found in medium-sized as well as in giant cells. All phases of the mitotic cycle (except prophase) are present. Both the number of multipolar division figures present and the variability of their configurations is suggestive of the conditions found in certain neoplasms. Although no experiments have been made to establish the identity of the cells exhibiting multipolarity they appear to be fibroblastic in character.

The mechanism of action whereby multipolarity in somatic cells can be evoked experimentally is as yet unknown. Temperature variability, photosensitivity and content of culture media are suggested as possible agents. In the present experiments neither photosensitivity nor the content of plasma peculiar to an individual fowl proved to be a significant factor.

89. Possible conversion of chromonucleic acid into plasmonucleic acid during atypical spermiogenesis of Viviparus malleatus Reeve. Arthur W. Pollister and George I. Lavin, Columbia University and The Rockefeller Institute for Medical Research.

The atypical second maturation division is unequal; and all the chromosomes that are to degenerate enter the larger spermatid. These chromosomes, which are strongly basophilic and Feulgen-positive, soon disappear, a process which is unaccompanied by any compensatory appearance of other Feulgen-positive material in the cell. Cytological analysis shows that as the chromosomes disappear there arise in the cytoplasm many small granules, finally remain in the mature spermatozoon. These granules are basophilic. Photographs with a simplified quartz microscope show that the granules absorb light of wave length 2537Å to a degree comparable with that of the condensed chromatin of the typical normal spermatozoon. These two reactions, basophily and absorption near 2600Å, are evidence that the granules contain the two nucleotide components, phosphoric acid and base of purine or pyrimidine type. Since the granules arise only as the chromosomes disappear it seems likely that the phosphoric acid and base are derived from the chromonucleic acid of the chromosomes. An apparently simple change that explains both the disappearance of the Feulgen reaction and the content of phosphoric acid and base in the granules is that the chromonucleic acid (desoxyribose) of the chromosomes has become plasmonucleic acid (ribose) in the granules, leaving the nucleotide groupings intact. However, in the absence of a cytochemical test for ribose, the possibility of more extensive molecular reorganization is not excluded.

Ecology

90. Relation of diatoms to salinity in Chesapeake Bay. R. P. Cowles and C. E. Brambel, The Johns Hopkins University and Mercy Hospital.

As is generally known, the water of Chesapeake Bay is brackish. The saline water of the Atlantic Ocean enters at its southern end and makes its way toward the northern end along the bottom of the deep channel subject to tidal fluctuations, as the senior author has shown in his investigations for the Bureau of Fisheries. The saline water is covered over during most of the year by much fresher water, entering from many small tributary rivers, along the shores of the Bay, which mixes to some extent, and, in the spring, quite thoroughly, with the saline sea water, thus producing the brackish condition.

These brackish waters vary in salinity (determined and studied by R. C. Wells) from about 5‰ (5 parts per mille; 5 grams of salts in solution in 1000 grams of water) near the northern end of the Bay to about 30‰ at the southern end which leads into the Atlantic Ocean.

Most of the diatoms (identified by Wolfe and tabulated by Cunningham) that enter the ocean, belong to the Neritic Group but some of them are Oceanic. They are carried up the Bay but north of Baltimore most of them disappear. There are also fresh-water diatoms coming in from the rivers but only a few of these survive even in the fresher parts of Chesapeake Bay.

91. An ecological and taxonomic study of the marine intertidal mites of Long Island Sound. Irwin N. Newell, Yale University. (Introduced by G. E. Hutchinson.)

The intertidal zone is characterized by a mite fauna comprising two broad categories — the Halacaridae or marine mites proper, and a large array of species of terrestrial or freshwater origin from every superfamily of the Order Acari. Of the mites of terrestrial or freshwater origin, many species are found only occasionally in the intertidal zone where conditions permit, others inhabit this zone preferentially but not exclusively, and still other species, or even genera are found only in the intertidal zone. The fauna of Long Island Sound shows considerable similarity to the fauna of western Europe and the British Isles. Collections from New Brunswick show that the mite fauna in that region is identical with that of Long Island Sound. On the other hand, collections from Florida have yielded no species identical with those of the northeastern United States. Factors affecting local distribution of intertidal forms are salinity, exposure to wave action, tides, and distribution of plants or animals providing a substratum for the mites. A well-developed sand fauna is present, and the distribution of these mites is also affected by particle size and tide levels.

92. Age-groups and longevity in Turdus migratorious L. Donald S. Farner, University of Wisconsin.

A study of the data from 855 robins, Turdus migratorius migratorius L., banded as young at various localities throughout the range of this subspecies and subsequently recovered reveals that the average natural longevity of those which survive their first November 1 is 1.7 years. The mortality rate for all robins which have passed their first November 1 is slightly more than 50 percent per annum; this rate is probably the same in all age groups. After the first November 1 expectancy of further life is 1.2–1.3 years. This does not change with age, at least during the first three years of life.

93. Number of progeny related to social position in a flock of chickens. A. M. Guhl, D. C. Warren and L. F. Payne, Kansas State College.

The peck-order of 30 Rhode Island Red hens was determined. Three cocks, a Rhode Island Red, Barred Rock and White Leghorn with a dominance order in the sequence given, were introduced. The fertilizing capacity of the cocks was tested. From the third day on, all eggs were incubated and down color used as an indicator of the cocks which fertilized the eggs laid from April 11 to May 22, 1944.

The Red cock interfered with matings by his inferiors, and the Rock attacked the Leghorn. Most of the Leghorn's matings occurred during the second half of the experiment when the birds were given outdoor range. The Rock mated most frequently but many of his treadings were incomplete due to interference. Of the observed matings terminating in juxtaposition of vents, the Red participated in 57 per cent, the Rock in 39 per cent and the Leeghorn in 3 per cent. 51 per cent of the chickens were red, 35 per cent black and 13 per cent white.

During the time observed, the hens of the middle third of the peck-order were trod a mean of 5.1, the top third 4.7 and the lowest ten hens 4.5 times. The mean number of eggs laid were 25.0, 22.2 and 19.6, top to bottom levels respectively; and from which an average of 16.6, 12.5 and 10.5 chicks were hatched. Egg production excepted, variability as shown by standard deviations was greater at the lower two thirds of the social order.

Embryology

94. Agglutination of starfish sperm by homologous egg water. Charles B. Metz, Wesleyan University. (Introduced by Albert Tyler.)

There are a number of species of animals whose sperm are not ordinarily agglutinated by homologous egg water. This fact was one of the early objections to F. R. Lillie's view that fertilizin was of general significance in the fertilization of animal eggs. However, in two such species, (Patiria and Urechis) there has been obtained (Tyler, '44) evidence of the presence in egg water of a specific substance that reacts with the sperm but fails to cause agglutination. Also, it has been shown (Tyler, '41; Metz, '42) that sea-urchin fertilizin can be converted into a non-agglutinating, but still reactive, form. It is now found that the addition of hen's egg white or of lobster serum (absorbed with starfish sperm) enables the egg water of starfish (Patiria miniata, Pisaster ochraceus, Astropecten armatus) to agglutinate homologous sperm. The effective agent in hen's egg white is relatively heat stable, nondialyzable, precipitable by acetone or alcohol but not by saturated ammonium sulfate. The agglutination is dominantly species specific. Absorption tests show that the sperm combine with the homologous fertilizin in the absence of the agglutination-enabling agent.

95. Regeneration in the frog. C. S. Thornton, Kenyon College.

Natural regeneration in the adult frog has been reported in only 2 cases (Gadow, '01). In the past year, of 200 adult R. pipiens shipped to us by Ward's and Turtox, 3 showed atypical limb regeneration. In 2 of these cases, the right hind foot had been lost and undifferentiated spikes, 6 and 6½ mm. long, had regenerated. In the third case, 2 digits of the left fore foot had been lost and blastema-like regenerates, 1½ mm. long, appeared at the wound surfaces. Morphogenesis failed to take place in all 3 cases. In the laboratory, 6 adult R. pipiens underwent amputation of the right fore foot. In 2 of these, blastema-like regenerates, 3 and 4 mm. long, developed after 3 months but failed to undergo further morphogenesis. Sections of the above 5 regenerates revealed a central, irregular rod of cartilage in each surrounded by masses of dense connective tissue.

In a second experiment, 25 frogs underwent amputation of the right fore limb at levels proximal to the elbow. No signs of regeneration were discovered in any of these. It is tentatively suggested that adult R. pipiens retains a limited regenerative ability of the limb but at levels distal to the elbow only.

96. INDUCTION OF SCAR TISSUE AND CARTILAGE IN LIMBS OF LIZARDS AFTER AMPUTATION. Lucie Welles Barber, Smith College. (Introduced by S. Meryl Rose.)

Limbs of lizards fail to regenerate after simple amputation. Several observations of conditions have been made which may be useful in understanding the type of development which follows amputation. First, skin almost completely closes over the amputation surface, leaving a reduced surface under which limited dedifferentiation occurs. Second, some of the limb tissues shrink back from the original amputation surface, leaving old bone and old dermis in the vicinity of the blastema cells which have formed beneath the epithelium. Third, from the undifferentiated cells of the potential blastema only scar tissue and cartilaginous caps on the ends of bones are formed and growth ceases.

A comparative histological study was made between limbs from which dermis or bone had been removed at the time of amputation, and limbs which had undergone simple amputation only. Beneath a dermis-free surface there is a greater amount of cell breakdown than after simple amputation. Much less scar tissue and as much or more cartilage forms. Following the removal of bone, scar tissue predominates and less cartilage is formed. In the absence of either dermis or bone, more muscle fibers and more blood vessels differentiate.

These results indicate that dermis induces the formation of scar tissue and that bone induces the formation of cartilage. In the absence of either dermis or bone more of the undifferentiated cells are free to form other tissues.

97. THE PRODUCTION OF PROLIFERATIVE NODULES IN EMBRYONIC TISSUE BY SCRUB TYPHUS RICKETTSIAE. Captain Howard L. Hamilton, Sn.C., Division of Virus and Rickettsial Diseases, Army Medical School, Washington, D. C.

A large nodular mass of tissue is formed on the chick chorioallantoic membrane in response to inoculation with the rickettsiae of scrub typhus. The lesion, which is usually 8–10 mm. in diameter and 4–6 mm. thick after seven days of growth, consists of a shallow ulcerous concavity on the outer surface where the inoculum was placed, and an inner tumor-like nodular mass which projects into the allantoic sac. Proliferation of the mesenchyme is largely responsible for the formation of nodules, although there is some highly-branched, papillomatous growth of the allantoic epithelium. The mesenchyme, which may exceed 20 times its normal thickness, contains centers made up of necrotic cells fringed by rickettsiae. Rickettsiae also occur in fewer number throughout the lesion, in epithelium as well as mesenchyme. Surrounding each center of rickettsial growth is a layer of primitive mesenchyme cells which resemble fibroblasts. The same type of cell underlies the main ulcer. There is much infiltration of the mesenchyme with wandering ''round cells'' — embryonic mononuclear leucocytes which resemble definitive lymphocytes. These ''round cells'' are particularly abundant at the periphery of the necrotic areas where they appear to ingest many of the rickettsiae. The abnormal growth of both mesenchyme and epithelium as well as the high degree of vascularization of the lesion indicate that the rickettsiae of scrub typhus may have growth-stimulating properties comparable to some of the papilloma viruses or the nodule-forming bacteria.

98. SUBCUTANEOUS VS. DERMAL MELANOPHORES. Hans Elias, Middlesex Veterinary School.

Dermal or adepidermal melanophores exist in urodelan and discoglossidan larvae. Subcutaneous melanophores exist in some urodelan and all anuran larvae; they are conspicuous in the latter. DuShane ('43) declares that embryologically all of them are equivalent and calls them all ''dermal''.

Indeed, all derive from the neural crest. Bytinski-Salz ('38) showed this first for subcutaneous melanophores in Bombina. Elias, Quigg, and Sauris ('42) demonstrated that subcutaneous differ from dermal melanophores, experimenting with Rana sylvatica. New experiments with Rana palustris confirm this: Neural crest implants give rise to subcutaneous melanophores. But if the neural crest is unilaterally exstirpated, the pigment pattern becomes normal nevertheless. Baltzer ('41) showed that Hyla neural crest, implanted unilaterally into Triton gave rise to melanophores which spread out transversely to the other side. Baltzer did not notice that Hyla melanophores are subcutaneous. Numerous experiments, e.g. by DuShane ('35) and Twitty ('44) on urodeles prove that dermal (= adepidermal) melanophores remain on the side of origin.

The basic embryologic difference between dermal and subcutaneous melanophores is therefore: The neural crest furnishes dermal (= adepidermal) melanophores for its own side only, but it sends subcutaneous melanoblasts to the opposite side as well. A tentative explanation is offered: The system of subcutaneous melanophores is a harmonious equipotenial system, the system of dermal melanophores is not.

99. THE EFFECT OF EXPOSURE TO TEMPERATURES OF 5–10°C. ON THE SURVIVAL AND DIFFERENTIATION OF EMBRYONIC THYROID TISSUE CULTURES. Esther Carpenter, Smith College and The Ohio State University.

Sixty-three pairs of eight day chick embryo thyroids were grown in plasma and chick embryo extract by the cover slip method for four to six days. One member of each pair was grown throughout at 38°C. Confirming previous results, these showed differentiation of colloid and follicles similar to that found in the intact embryo. The remaining thyroids were subjected to temperatures of 5–10°C. for one or more days during the period grown. Material for these experiments was supplied by the Poultry Department of The Ohio State University from White Leghorn stock.

Cultures exposed immediately to a low temperature for one day showed no apparent harmful effects when grown at the normal temperature for the remainder of the period. Increase in the length of exposure resulted in the appearance of areas of disintegration in the culture when grown at 38°C. One of five cultures cooled four days before being placed in the incubator survived the treatment. Exposure of cultures to low temperature on the second, third, fourth and fifth days was increasingly disastrous. None of the cultures survived after one day at 5–10°C. on the fourth or fifth day of cultivation. This corresponds to the time of early follicle formation.

100. CYCLOPIA. A. M. Reese, West Virginia University.

A short discussion of cyclopia in general with a brief description of a cyclops lamb dissected by the author.

101. PARALLELISM OF THE DETERMINATION OF SCALLOPING AND PLEXATION IN THE WINGS OF DROSOPHILA. Richard B. Goldschmidt, University of California.

Phenotypes of 5 bs-alleles, their compounds and combinations with a deficiency always show the seriation in the fifth cell of dot, dash, antler, web, extreme web, blister in one wing, both wings, extreme blistering, sac-wing. In the presence of the deficiency a parallel series affects all wing cells. The px effects produced in different alleles and compounds begin in the first, second, and fourth cell, reaches the fifth in higher grades; thus bs-action starts posteriorly and spreads anteriorly and px vice versa. Combination effects of both are additive. In development third and fourth veins are ahead. The second follows, the fifth is far behind, the last being the cross-vein. As concrescence of the membrane is involved in veins and extra-veins beginning plexation will occur in the region of the cross-vein and fifth cell if determined late in development. The bs series thus indicates a relation between increasing plexation and time of determination. The px effect, however, follows a different pattern and the difference between the two patterns (posterio-anterior and vice versa) parallels that of different patterns of the scalloping type. In the latter case one pattern was shifted into the other one by changing the speed of development (Braun). Scalloping and plexation can both be obtained as phenocopies by temperature action, and plexation can be enhanced by the same chromosome rearrangements which enhance scalloping as a position effect. A common basis of embryological determination within the wing, may be a gradient, is suspected.

102 Phenogenetic studies of the aristapedia alleles of Drosophila pseudoobscura.[1]

Claude A. Villee, University of North Carolina.

Aristapedia-Dobzhansky (ar^D) and aristapedia-Spassky (ar^s) are homoeotic mutants of Drosophila pseudoobscura which change the antennae into tarsi. The former is the stronger allele, producing under normal conditions a complete change of the arista into a tarsus-like appendage; the latter is a weaker allele which changes only the arista into a slender, segmented tarsus and leaves the basal part of the antenna more or less normal. High (29°C.) and low 15°C.) temperature treatments applied to developing larvae and pupae of these stocks gave results similar to those reported for the aristapedia alleles of D. melanogaster: heat treatments shift development of the antennae of aristapedia flies toward the tarsus phenotype, while cold treatments shift development toward the tarsus phenotype. Treatments were effective if begun 0 to 5 days after egg deposition, but were ineffective if begun 6 or 7 days after development began. This indicates the genes have "homologous" actions — they affect the same part of the developmental reaction system in the same way and at corresponding times of development in the two species. The genes are probably homologous in the true sense of having common origins since the pseudoobscura alleles are in chromosome II and the melanogaster alleles are in chromosome IIIR, which are known to be homologous. Whether or not they are homologous in the strict sense, they do have similar actions and the term "homophenic" is suggested to indicate genes in different species which affect the same part of the developmental reaction system in the same way at corresponding times in developmental and thus produce identical phenotypes.

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[1] I want to thank Professor Dobzhansky and Mr. Spassky of Columbia University for generously making available the aristapedia stocks used in this study.

Endocrinology

103. The thyrotrophic potency of the pituitary of the albino mouse.

A. Elizabeth Adams and Arlene M. Mothes, Mount Holyoke College.

Anterior pituitaries of male and female albino mice of one strain were tested for thyrotrophin at three ages by the 24-hour chick assay method in which one chick unit is considered the amount of hormone causing a 50% increase over that of controls in average thyroid cell height of 2-day-old chicks 24 hours after subcutaneous AP implantation. It was found that the thyrotrophic potency per gram of fresh AP tissue in each sex increased from prepuberty (26–27 days old: ♂, 590 C.U.; ♀, 970 C.U.) to puberty (40–41 days old: ♂, 676 C.U.; ♀, 1,006 C.U.) and decreased as the mice aged (82–83 days old: ♂, 572 C.U.; ♀, 402 C.U.) and that it was greater in females than in males at the earlier ages but less at the oldest.

The thyroid cells heights of the mice furnishing APs for thyrotrophin assays were also determined. The average thyroid cell height in males rose from $5.11 \pm 0.04\,\mu$ at 26–27 days to $5.79 \pm 0.07\mu$ at 40–41 days and then fell to $5.41 \pm 0.04\,\mu$ at 82–83 days, whereas that of females at the same ages dropped from $5.58 \pm 0.06\,\mu$ to $4.96 \pm 0.06\,\mu$ and then rose to $5.98 \pm 0.06\,\mu$. If activity of the thyroid as manifested in thyroid cell height is indicative of thyrothophin-release and if the AP thyrotrophin-content is indicative of thyrotrophin-storage, it seems that the male maintains a more nearly balanced release-storage thyrotrophin-relationship than the female, whose AP appears active in both storage and release at 26–27 days, but storing more than releasing at 40–41 days and reversing this relationship at 82–83 days.

104. CONCENTRATION OF URINARY HYPOPHYSEAL HORMONES BY ULTRAFILTRATION. Aubrey Gorbman, Wayne University.[1]

Criticism of current methods for concentrating urinary hypophyseal hormones is usually directed against hormonal loss and denaturation attending their use. These difficulties are encountered in the precise adjustment of conditions for complete precipitation, in dialyses, and in the denaturant or solvent action of reagents used in washing precipitates. The simplicity of the method presented here for concentration of excreted hormones eliminates most of these troubles.

Urine or aqueous solutions of hormone are ultrafiltered through a collodion membrane (Wilson and Holiday, Biochem. Jour., 27: 1096) sealed with rubber washers into Seitz filters for volumes up to 100 cc., or larger vessels similarly constructed of 6-inch pipe and flanges for volumes up to 3 liters. Pressure of about 6 atmospheres (80–90 pounds/in.^{2}) is applied through a tire valve with an auto tire pump. The membrane is dried immediately in vacuum and dissolved in 15 cc. alcohol-ether in a centrifuge tube. All collodion is removed by successive washes of alcohol-ether and centrifuging. The dried hormone-containing precipitate dissolves readily in water for bioassay.

Urines so processed and assayed for gonadotropin in 21-day female mice gave values of 5–15 mouse units/24 hours for normal men, less than 5 units for 2 normal children, and 5 units for a 3-year-old male ''renal dwarf.'' In critical tests complete retention by the collodion membrane has been found for known solutions of chorionic gonadotropin, FSH, and intermedin in purified form or in aqueous hypophyseal extracts.

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[1] Present address: Department of Anatomy, Yale University School of Medicine.

105. PITUITARY CHANGES IN AGING CAPONS. Fernandus Payne, Indiana University.

In 1942 I described mitochondrial changes in basophiles of old hens and cocks and also mentioned that similar changes were found in capons and ovariectomized birds. A further study of capons not only verifies the earlier observations but demonstrates that the changes begin earlier and become much more pronounced than in cocks of the same age. The changes appear as early as 56 days in capons while they have not been observed prior to 98 days in young cocks. In capons 4 and 6 years old changes are much more pronounced than in cocks 6 to 9 years old. Time of appearance and extent of modification, however, are variable factors. Changes are found in chromophobes as well as basophiles and consist of modifications of the granular mitochondria into vesicular-like structures which may fuse to form larger bodies. These bodies may increase in size until they fill the cells, in which case the cells disintegrate. Whole cords of cells may be so affected and in 6-year-old capons only a few basophiles are unmodified, at least, to some degree.

In my earlier paper I spoke of these mitochondrial modifications as one of several changes which accompany aging. In the absence of gonads changes occur earlier and become more pronounced. What is the significance of these changes and why are they more marked in capons than in controls? These are questions still to be answered.

106. POSSIBLE CONTROL OF THE LATERAL VAGINAL CANAL IN THE OPOSSUM DURING REPRODUCTION. Olin E. Nelsen, University of Pennsylvania.

In the normal estrous cycle, the lateral vaginal canal hypertrophies rapidly during the early estrous condition. At estrus it is greatly distended and a well-developed lumen with desquamation of cells is evident. Shortly after estrus this canal recedes again to a resting condition, although at the same time the uterus continues to enlarge. At this time the corpora lutea are well formed. Injections of follicle stimulating hormone (Ayerst, McKenna and Harrison) during the anestrous condition of the opossum will stimulate the lateral vaginal canals, uteri and fallopian tubes to hypertrophy. Injections of FSH plus progesterone

(Ciba) produces well-developed uteri, but the lateral vaginal canals show little if any response. Injections of progesterone into an animal previously stimulated with FSH will continue uterine development, but tends to suppress the lateral vaginal canals and fallopian tubes.

107. THE EFFECT OF SOME STEROID HORMONES ON THE SEMINAL VESICLES OF THE MOUSE. H. J. Clausen, University of Colorado School of Medicine.

Experiments are reported dealing with the effects of intraperitoneal injections of progesterone and desoxycorticosterone acetate on the seminal vesicles of castrate mice.

All animals were castrated at 16 days of age. Injections were started when the mice were 30 days old. Forty daily injections of 0.5 mg. of crystalline progesterone in oil were administered to one series and 40 daily injections of 0.5 mg. desoxycorticosterone acetate were given to another series. The control series consisted of a group of castrate non-injected mice and also a group of sesame oil injected castrate mice. All animals were sacrificed for histological examination at 73 days of age.

The results show that in the mice of the control groups the columnar vesicle epithelium had differentiated and was possibly being maintained by the hypertrophied X-zone of the adrenal. In the desoxycorticosterone acetate injected series, an incomplete degeneration of the columnar epithelium of the seminal vesicles was in evidence and the X-zone of the adrenal of this series also showed a partial degeneration. In the progesterone injected series the vesicle epithelium was not only being maintained, but evidence of secretory activity was also present. The X-zone of the adrenals in this series had undergone partial degeneration. It would appear that the injected progesterone was directly responsible for the maintenance of the columnar epithelium of the seminal vesicles in this series.

108. STUDIES ON THE EFFICACY OF DESOXYCORTICOSTERONE ACETATE IN ADRENALECTOMIZED RATS ON (A) A LOW SODIUM CHLORIDE DIET, (B) A DIET DEFICIENT IN CYSTINE. Wilburn J. Eversole, The Rice Institute.

In a previous report (Eversole, '44) evidence was presented that desoxycorticosterone acetate (DCA) is effective for at least 10 days in the adrenalectomized rat when the sodium chloride intake is minimal. These observations have been extended so that the experimental period covers a 20-day period. A total of 18 young rats was given a sodium chloride deficient diet: 11 of the animals were placed on the diet for a 10-day period, adrenalectomized, given 0.2 mg. DCA daily for 10 days and maintained on the deficient diet until death; 7 rats were adrenalectomized, given the salt deficient diet and injected with DCA for 20 days. The response in these two groups was similar and the results were averaged. Thirteen of the 18 animals survived the experimental period and gained an average of 1.5 gm./day. These results suggest that DCA is effective for relatively long periods of time when the salt intake is minimal.

Seven young male rats were given a purified diet deficient in cystine, adrenalectomized, and injected with 0.2 mg. DCA daily until death. None of these animals survived more than the 10-day experimental period, the average survival being 6.9 days; the average weight gain was 1.2 gm./day. This experiment suggests that the adrenalectomized rat cannot be maintained on DCA when the diet is severely deficient in cystine. Further experiments along these lines are now in progress.

109. ACTION OF DESOXYCORTICOSTERONE ACETATE IN THE IMMATURE MOUSE. H. D. Slobodien and J. H. Leathem, Rutgers University.

Desoxycorticosterone acetate (percortin, Ciba) was administered subcutaneously to 24-day-old female mice in total dosages of 2.5 mg. over either a 10-, 20- or 30-day period. The steroid was also injected in daily dosages of 0.25 mg. or 1.0 mg. for 20 days. Comparison with littermate controls revealed that body weight increase was not impaired. The weights of the kidneys, adrenals and ovaries did not differ from the control organ weights. In no case was a disappearance of the adrenal X-zone observed. Follicular growth was normal in all mice but formation of corpora lutea was suppressed in mice receiving either the 5 or 20 mg. dosages. The apparent number of vesicular follicles was reduced in the ovaries from mice injected with the 20 mg. dosage in that these ovaries contained much more stroma than their controls. Uterine weight was stimulated slightly by the 5 and 20 mg. dosages but not by the small dosages.

110. EFFECTS OF THIOUREA, THIOURACIL AND ESTROGENS ON RESISTANCE OF RATS TO LOWERED BAROMETRIC PRESSURES.[1]

E. D. Goldsmith, Albert S. Gordon annd Harry A. Charipper, Washington Square College of Arts and Science, New York University.

It has been found that females tolerate lowered barometric pressures better than males (Gordon, Tornetta, D'Angelo and Charipper, '43). The question as to whether the estrogens are concerned in this response was investigated. Eighteen adult female and 16 adult male rats were fed a diet containing 0.5% thiourea for 12 days. At this time, 9 of the females and 8 of the males were given daily injections of 0.05 mg. estradiol dipropionate in sesame oil for 9 days along with the thiourea treatment. The remaining 9 females and 8 males were injected with sesame oil and continued on thiourea for the same 9-day period. Eight additional males and 8 females were injected with 0.05 mg. estradiol dipropionate for 9 days; there had been given no thiourea treatment. Eight males and 8 females injected with sesame oil alone served as controls. All animals were then subjected to lowered barometric pressures (males — 190 mm. Hg, 34,000 ft.; females — 160 mm. Hg, 37,000 ft.) for 2 hours. Ninety per cent of the thiourea-fed animals and only 20% of the others survived the exposure. The estrogen was found to be without effect on altitude tolerance in both the normal and thiourea-treated groups.

A similar experiment was conducted to determine the effects of estradiol benzoate and diethylstilbestrol on the resistance of normal and thiouracil-fed males. Although thiouracil afforded considerable protection against the anoxia, no beneficial or inhibitory effects of the estrogens were noted in either the thiouracil-treated or normal groups of rats subjected to the lowered pressures.

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[1] Aided by a grant from the Commonwealth Fund.

111. FEATHER GROWTH RATES IN THYROIDECTOMIZED BROWN LEGHORN FOWL.

Ben B. Blivaiss and L. V. Domm, Whitman Laboratory of Experimental Zoology, The University of Chicago.

Measurements were made on alternate days in thyroidectomized and normal adult males and females. Comparable areas were selected in each of four feather tracts and 25 regenerating feathers per tract were measured in each bird.

In five thyroidectomized males, at 50 days after plucking, average length of regenerating anterior breast feathers was 31.2, posterior breast 37.5, back 32.4, and saddle 35.2 mm. compared to a length of 75.9, 87.2, 78.7 and 67.0 mm. respectively in a normal male. In thyroidectomized males, the average two-day growth increment observed during day 20–40 on regenerating anterior breast feathers was 1.85, posterior breast 2.24, back 1.94, and saddle 1.94 mm. compared to a rate of 4.59, 4.90, 4.32 and 3.55 mm. respectivley in a normal male. Posterior breast feathers in thyroidectomized males, as in normal males, show greatest growth increment.

In 4 thyroidectomized females, at 48 days after plucking, the average length of regenerating anterior breast feathers was 29.1, posterior breast 3.93, back 33.5, and saddle 29.4 mm. compared to a length of 64.5, 71.1, 70.8 and 68.4 mm. respectively in a normal female.

In thyroidectomized females, the average two-day growth increment observed during day 20–40 on regenerating anterior breast feathers was 20.1, posterior breast 2.27, back 1.82, and saddle 1.68 mm. compared to a rate of 4.03, 4.39, 4.37 and 3.89 mm. respectively, in a normal female.

The reduced feather growth rate observed in thyroidectomized fowl is probably a direct metabolic effect, but its invariable association with body dwarfism and juvenile reproductive system suggests pituitary mediation.

112. The effect of thyroxin in the thiouracil-treated brown Leghorn capon. Mary Juhn, University of Maryland.

Thiouracil fed to adult Brown Leghorn capons in daily doses of approximately 0.4 gm. per day causes a replacement by red of originally black feather segments and a reduction in barbulation as has been found by others to follow thyroidectomy in this parti-colored breed.

Under such experimental conditionns the black and solid male or capon breast feathers come closely to resemble the saddle feathers of the normal male, that is, breast feathers in growth become orange-red in color and long and lacy in shape.

Thyroxin in doses up to 5 mg. given by subcutaneous injection induces a deposition of melanin in the normal saddle feather with which is associated an increase in barbulation; the treated saddle feather becoming black in color and rounded and solid in outline.

Single doses of 2 mg. thyroxin given to each of four continually thiouracil-treated capons which all were forming red and lacy breast feathers caused a re-appearance of the melanin and barbulation normal to this region. The response to thyroxin was somewhat more slow than had been earlier found in untreated capons, otherwise the reaction obtained shows, as has been demonstrated by others for mammals, that modifications originating in the ingestion of thiouracil may be counteracted by the simultaneous administration of thyroxin.

113. Paraxanthine and thyroid function.[1] Albert S. Gordon, Harry A. Charipper and E. D. Goldsmith, Washington Square College of Arts and Science, New York University.

Carter et al. ('43) have claimed that paraxanthine (1, 7-dimethylxanthine) is a highly effective anti-thyroid substance as shown by its action in converting the "winter" to "summer" heart in the frog and in reducing the basal metabolic rate in rats. It became of interest to determine the effect of this agent on amphibian metamorphosis and on the resistance of rats to lowered barometric pressures. Thirty-eight Rana pipiens tadpoles with a mean hindlimb length of 4.0 mm. were injected pleuroperitoneally once every second day with 0.25γ of paraxanthine (American Cyanamid Co.). Thirty-eight larvae served as untreated controls. Since no apparent effect appeared to be exerted by the drug, the dose was increased to $.5\gamma$ on the 6th injection, to 1.0γ on the 8th injection, to 2.0γ on the 12th injection, to 3.0γ on the 15th injection and 4.0γ on the 18th injection; this latter dose was maintained for the remainder of the experiment; a total of 36 injections was administered. The drug was found to be without significant effect on the metamorphosis of these animals as judged by the rate of hindlimb growth and time of fore limb extrusion.

Twenty-four adult male rats were injected with 20 to 50γ paraxanthine once daily for periods varying from 1 to 7 days. They were then exposed to pressures of 190 mm. Hg (34,000 ft.) and the time of cessation of respiration noted. The drug was found to have no effect on the resistance of any of these rats to the reduced pressures. In addition, no consistent effects of the drug on the basal metabolic rates in these animals were detected.

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[1] Aided by a grant from the Commonwealth Fund.

114. Phosphorus turnover in brown fat as demonstrated by radio-active phosphorus. Jae L. Littrell, Dorothy Martin and Carl G. Hartman, University of Illinois.

To determine the phosphorus turnover of the subscapular brown fat (''hibernating gland'') in the rat, radioactive phosphorus (prepared by Dr. P. G. Kruger in the University of Illinois cyclotron), after conversion to Na_2HPO_4, was fed (in milk by stomach tube) to adult rats. The animals were sacrificed 96 hours later. Since it was found that the blood of such rats is also radioactive, the animals were perfused with saline followed by India ink. Specimens of brown fat, body fat, ovaries, adrenals, thyroid, liver, spleen, pancreas, muscle and brain were fixed, dehydrated, embedded and sectioned 25 micra in thickness and the sections dipped in 3% celloidin. A section of each tissue was laid on an x-ray film to which it was exposed for 48 hours. Good radiographs resulted. They clearly showed the substituted phosphorus to be high in all glandular tissue and equally high in the brown fat, much less in body fat. In correlation with this fact the assay of brown fat for phosphorus was 0.1286%, that of adipose tissue 0.0166%. This study is part of a comprehensive study of brown fat.

115. Acquired resistance to water intoxication.[1] Mildred Liling and Robert Gaunt, Washington Square College of Arts and Science, New York University.

It is known that the resistance or tolerance of animals to stresses (drugs, toxins, trauma, etc.) can be increased above normal by administering the damaging stimuli in sublethal amounts for various periods of time.

This is to report that a similar resistance to the toxic effects of excess water, given orally, can be developed rapidly in rats.

From previous work on normal rats in this laboratory it was known that the administration of 13 doses of water (3 cc. per 100 sq. cm. of body surface) at half-hour intervals results in death in many cases and convulsive seizures or collapse in nearly all cases.

Rats were ''trained'' to withstand such amounts of water as follows: one dose was given on the first day, two on the second, etc., until five were given on the fifth day. On the sixth day the standard 13 doses were given. In 77 pre-treated animals no deaths occurred, and convulsions or collapse were seen in only 2 (12%) of the cases. In controls run simultaneously collapse and convulsions occurred in 100% of the cases and death in 73%. Body temperature was also better maintained in the treated group.

One of the main reasons for the protection was that pre-treated animals had acquired the ability to maintain a rate of diuresis faster than that of normal animals.

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[1] These experiments were aided by a grant from the Josiah Macy, Jr. Foundation.

116. The occurrence of burst atretic follicles in the class Aves. David E. Davis, United States Public Health Service.

Ovarian follicles containing a large amount of yolk undergo atresia in an unusual manner. The follicular theca ruptures and the yolk material flows out but is retained by the mesothelium of the ovary. Burst atretic follicles differ from postovulatory follicles by the presence of yolk material and absence of a break in the mesothelium. This type of atresia was found in a few species of birds and described in detail (Davis, '42).

A series of slides of gonads of about 1000 Brazilian birds makes possible a survey of the occurrence of burst atretic follicles in many families. Such follicles were found in 67 species, representing 20 families. When the gonads were classified according to the phase of reproductive activity, nearly all burst atretic follicles were found in ovaries classified as progressing or active.

It is concluded that in the class Aves bursting atresia is the normal manner of elimination of ova containing a large amount of yolk material and that this type of atresia occurs commonly in reproductively active ovaries.

General Evolution

117. NATURAL HETERO-AGGLUTININS IN LOBSTER SERUM. Albert Tyler and Charles B. Metz, California Institute of Technology and Wesleyan University.

Lobster (Panulirus interruptus) serum normally agglutinates the sperm or the blood cells of a large variety of animals. These include various species of coelenterates (2 species) tested), polychaet annelids (3), elasmobranchs (1), echinoids (5), asteroids (4), holothuroids (1), ascidians (3), marine teleosts (4), amphibia (3), reptiles (2), birds (2), and mammals (5). It fails to agglutinate cells of species of gephyreans (3), pelecypods (4), gastropods (3), amphineurans (2) and fresh water teleosts (2). Where more than one species in each of the above groups has been tested, all within the group behave alike in regard to the ability of their cells to be agglutinated by the lobster serum. Absorption of the serum with cells of any one species of an agglutinable group, removes the agglutinins for all the species tested within that group but leaves agglutinins for all the species belonging to some or to all of the other groups. Thus absorption of lobster serum with Chaetopterus sperm removes the agglutinins for the other annelids but not for species belonging to any other group; absorption with echinoid cells removes not only agglutinins for that group but for asteroids, holothuroids and mammals as well, while leaving the agglutinins for other groups; etc. The tests provide evidence for the presence in lobster serum of at least seven distinct agglutinins each acting on the cells of one or more groups of animals. The animals of those groups that are represented by a common agglutinin presumably carry a similarly reacting structure (antigen) on the surface of their cells.

118. SYSTEMATIC RELATIONSHIP IN ANIMALS. Alan Boyden, Rutgers University.

The principles of phylogeny and taxonomy, framed in preceding decades, need significant revision if the ''new systematics'' is to achieve a well-rounded development and serve biology to its greatest capacity. It is often stated that the goal of taxonomy is the expression of phylogenetic relationships, but this is only one, and not the most important one, of the several goals of taxonomy. The grand object of classification everywhere is the same, viz., to group essentially like things together and to separate unlike things in accordance with their inherent natures. Of the two, phylogeny and taxonomy, the former has tended to assume an exaggerated importance since 1859 whereas the latter, taxonomy, is really the much more significant biologically. The phylogeny of many important animal groups is, and probably will continue to remain, uncertain because of the incomplete fossil records due to the absence of readily fossilized structures but these and all other animals must be classified. As a matter of fact the classifications of Ctenophora, Platyhelminthes, Nemathelminthes, and other major and minor animal groups are not seriously less convenient or biologically less significant because of the absence of fossil records, and the consequent lack of knowledge of their probable ancestry. The evolutionary pendulum has swung too far when it has resulted in the prevailing belief that new classification must always be ''based on phylogeny.'' Freed of its speculative abuses, taxonomy, though never simple, can progress as the other basic zoological sciences have, by becoming more objective, more quantitative, and more rational.

General Physiology

119. PROTEIN DETERMINATION IN THE PRESENCE OF AMMONIUM SULFATE. Lyle V. Beck. Hahnemann Medical College of Philadelphia.

Ammonium sulfate is extensively used in the fractionation of proteins. The determination of protein nitrogen in the presence of ammonium sulfate is made very tedious by the necessity of repeatedly washing the protein precipitate to remove all of the ammonia. However, the small amounts of ammonium sulfate carried down with proteins precipitated by trichloracetic acid have no measurable effect on the amount of Biuret color developed by these proteins (large amounts of ammonium sulfate give rise to an intense blue color).

The Biuret method of Robinson and Hogden (J. Biol. Chem. 135: 707, 1940) was modified to save time and to permit the accurate determination of as little as 4 mg. of protein. The trichloracetic acid precipitate obtained in a graduated centrifuge tube was dissolved to a volume of 10.0 cc., using 3% NaOH. 0.25 cc. of 20% CuSO4.5H20 was added, a paraffined cork inserted, and the tube shaken vigorously for 1 minute. One hour later the tubes were again centrifuged at 3500 R. P. M. for 10 minutes, and the supernatants filtered through no. 40 Whatman papers. Using a Coleman spectrophotometer set at 56 mμ, very close correspondence to Beer's Law was obtained for both Casein standards and enzyme fractions.

However, the amount of color varies somewhat for different proteins. This method is therefore suggested as a rapid method of obtaining approximate values for small amounts of protein present in different protein fractions, to be supplemented by protein nitrogen determinations when more accurate values are required.

120. THE DISTRIBUTION OF ALKALINE PHOSPHATASE IN THE FETAL MEMBRANES AND PLACENTA OF THE GUINEA PIG. Walter L. Hard, Department of Histology and Embryology, University of Maryland. (Introduced by Dietrich C. Smith).

The histological distribution of phosphatase (Gomori's method) has been analyzed in the placenta and associated membranes of gestation ages from 11 days to birth. Within the recently implanted blastocyst phosphatase occurs solely in the endodermal cells surrounding the embryonic disc, and those destined to form the yolk-sac. The superficial zone of decidual cells, surrounding the blastocyst, is negative in reaction but a deeper, more prominent zone is markedly positive.

Throughout the gestation period the labyrinth zone has a heavy concentration of phosphatase in contrast to the spongy zone which is consistently negative. The sub-placenta, allantoic vessels and mesenchyme, and giant cells are negative. In the ''junctional'' zone an occasional multi-nucleated cell mass shows a slight positive reaction. The decidual layer as a whole is negative but occasional cells show a prominent positive reaction.

Those cells of the endodermal yolk-sac which surround the uterus are strongly positive up to the 45–50 day period after which time cells in localized areas become negative and by 60–65 days the entire epithelium is negative. The endodermal yolk-sac cells from the region of the sinus terminalis and extending over the surface of the placenta are always negative. The amnion and chorion are negative.

Quantitative data on phosphatase concentrations are being accumulated and this, together with the histological distribution, considered in terms of the possible relationships with placental metabolism.

121. DEATH OF DORMANT PROTOPLASM. B. J. Luyet and P. M. Gehenio, St. Louis University and Biodynamica Laboratory.

Longevity records show that various forms of dormant protoplasm undergo a slow lethal reaction. In a study on sclerotized mycetozoa (Physarum polycephalum), kept in the laboratory where the temperature was about 20°C., except during summer when it often reached 32° and occasionally 38°, it was found that viability was reduced to 50% in about 12 months and lost completely in 24 months. A rise in temperature accelerates the lethal reaction. At 60°C., the viability was reduced to 50% in approximately 10 hours and lost completely in 20 hours. At 90°, 50% of the material was killed in 15 minutes and all in 45 minutes. The temperature coefficient, Q_{10} of that reaction (determined for 50% killing) averaged 3.5 between 100° and 50°, but increased to about 6 at the lower temperatures mentioned above. A further desiccation constitutes another injury factor. An exposure of sclerotia for 5 days to various desiccants, resulting in reduction of water content from

8–12% to about 4%, generally caused complete loss of vitality. High temperature and desiccation have a cumulative lethal effect. The particular features of these results from the point of view of mechanism of death are: (1) the rather low temperature coefficient as compared with that of most temperature-injury reactions; (2) the maintenance of that coefficient over a wide range of temperatures; (3) the fact that a further desiccation is injurious and even perhaps renders protoplasm more vulnerable to high temperatures, while desiccation generally increases the resistance of protoplasm to the action of temperature.

122. REORGANIZATION AND RESTORATION OF INDUCTIVE POWER IN PULVERIZED PAPILLAE IN BROWN LEGHORN CAPONS. Hsi Wang, Whitman Laboratory of Experimental Zoology, The University of Chicago. (Introduced by F. R. Lillie.)

Portions of saddle papillae representing the mid-dorsal halves, killed by immersion in boiling water and other means, when transplanted as ventral grafts to whole breast papillae caused, in the host feather, enlargement of the after-feather or lengthening of barbs in the fluff. This effect disappeared in later generations. Similar saddle papilla-inductors were cut up and ground to a mash with a little Ringer's solution; the pulverized papillae were divided into lots each about the size of a ventral graft and employed as such in host breast papillae. Among the resulting feathers, most of which were single feathers showing various donor features, were a few (1) complete and equal twins comparable in all respects to those derived from grafting ventrally intact saddle inductors.[1] When used as implants in empty breast follicles in quantities 4–5 times the ventral grafts, the same papilla-mash gave rise occasionally to single, feathers, twins and even triplets in single follicles. The frequencies of both (1) and (2) were roughly inversely proportional to the degree of pulverization to which the isolated papilla-inductors had been subjected, and upon this also depended the tract specificity of (2). These results are interpreted to mean that the power of induction ceases with the death of the cells comprising the inductor, and probably induction depends on some organization which can be restored provided the process of bringing about their disorganization has not, thereby, resulted in the death of these cells.

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[1] Lillie, F. R., and H. Wang, 1944, Physiology of development of the feather. VII. An experimental study of induction. Physiol. Zool., vol. 17, pp. 1–31.

123. EVIDENCE OF CONTROL BY SADDLE EPIDERMIS OF AXIAL GROWTH RATE IN FEATHERS OF COMPOSITE BREAST-SADDLE ORIGIN IN BROWN LEGHORN CAPONS. Hsi Wang, Whitman Laboratory of Experimental Zoology, The University of Chicago. (Introduced by F. R. Lillie.)

Measurement of more than 100 feathers derived from grafting of dorsal (BD, SD) and ventral (BV, SV) one-third papilla sectors in and between breast (B) and saddle (S) tracts[1] has revealed a significant influence of the S component on feather length. The following average lengths (in mm.) bring out the difference between B and S grafts in B hosts: B/BD = 108, B/SD = 129.8; BD/B = 98.8, SD/B = 121.5; B/BV = 103, B/SV = 112.8; BV/B = 109.2, SV/B = 118.7. Conversely, normal S length was approximately retained when S was host, thus: S/SD = 162, S/SV = 145.5, SD/S=152. SV/S=150.7, S/BD = 160.6, S/BV = 147, BD/S = 135.7, BV/S = 138.6.[2] Recent experiments have confirmed this finding. When pulverized SD's served as ventral grafts to whole B papillae (see abstract no. 122), resulting feathers that displayed definite S characters were 30% longer than controls while those with the effect confined to the after-feather showed but 10% increase. Attempts were then made to correlate the increased length with growth rate in B feathers after grafting ventrally (1) a whole ventral S half-papilla, (2) a whole ventral B half-papilla, and as control, (3) S papillae incorporating a whole ventral B half-papilla. Feathers obtained from (1) and (2) were, respectively, 25% and 10% over normal B length, with correspondingly reduced growth rate over a prolonged regeneration period. No such effect was found in (3). Finally, tuft (rhachisless) feathers derived from combined B and S ventral half-papillae were found to grow at a much more reduced rate than those from two B ventral halves. These results suggest that while normally growth rate is tract specific, the rate issued from a composite papilla is nevertheless under the control of the slow-growing partner, S.

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[1] See table 1, Lillie, F. R., and H. Wang, ('44), cited in abstract no. 122.

[2] In all designations single character represents host, double ones, graft; numerator indicates dorsal, denominator, ventral positions.

124. THE RATE OF PULSATION OF THE POSTERIOR CONTRACTILE VACUOLE OF PARAMECIUM WOODRUFFI AND PARAMECIUM CALKINSI. John A. Frisch, S. J. Canisius College.

The following hay infusion cultures of Paramecium woodruffi and Paramecium calkinsi were set up: fresh water, 25%, 50%, 75% and 100% sea water. (Woods Hole, Mass.). Five months after these cultures had been established, the rate of pulsation of the posterior contractile vacuole of approximately 200 individuals from each culture was observed and recorded. The results show that the rate of pulsation of Paramecium woodruffi varies with the concentration of the sea water; the time interval successive pulsations averaging 13 sec. in fresh water, 22 sec. in 25% sea water, 32 sec. in 50% sea water, 47 sec. in 75% sea water and 65 sec. in 100% sea water. In contrast the results show that the rate of pulsation of Paramecium calkinsi is independent of the sea water concentration and is the same in fresh water and all concentrations of sea water; the time interval between successive pulsations averaged 23 sec.

125. THE RATE OF ADAPTATION OF PARAMECIUM CAUDATUM TO SEA WATER (WOODS HOLE, MASS.). John A. Frisch, S. J. Canisius College.

A fresh water-hay infusion culture of Paramecium caudatum was successfully subcultured into a 5% seawater-hay infusion medium. At intervals of 5 days, this 5% sea water culture was progressively subcultured into 10%, 15%, 20% and 25% sea water-hay infusion media. All but the 25% culture took and are still flourishing after 2 years; the 25% culture survived only 7 weeks. In contrast to this rapid adaptation from fresh water to 20% sea water, further attempts to raise the 20% culture to 25% failed until the 20% culture was 6 months old. This 25% culture is now 1 year and 5 months old. Attempts to raise the 25% culture to 30% failed until the 25% culture was 9 weeks old. Then at intervals of 2 weeks this 30% culture was progressively raised to 35, 40, 45 and 50% sea water. All these cultures are now over a year old. Again in contrast to the rapid adaptation from the 30% to the 50% concentration. it required 6 months to raise the 50% culture to 55% (now 26 weeks old); 6 weeks to raise the 55% culture to 60% (now 20 weeks old); and 6 weeks to raise the 60% culture to 65% (now 14 weeks old). Thus far no successful 70% culture has been established.

126. FURTHER OBSERVATIONS ON FACTORS INFLUENCING THE HYPOXIC SURVIVAL OF MICE SUBJECTED TO BAROMETRIC DECOMPRESSION. Wm. A. Hiestand and Helen Rogers Miller, Purdue University.

The effects of such factors as rate of barometric decompression, carbon dioxide, starvation, carrot diet, dehydration, and air temperature on hypoxic survival of mice have been investigated. Our results have demonstrated the following facts: Mice tolerate hypoxia best if slowly decompressed although prolonging the rate too much has a detrimental effect. Carbon dioxide has only a minor effect on hypoxic survival not in itself being beneficial to greater tolerance. Inanition decreases hypoxic resistance in direct proportion to the duration of starvation. An exclusive diet of carrots for 10 days increases resistance of mice to anoxia which is apparently related to water loss by the body. Dehydration up to 20% of total body weight significantly increases hypoxic resistance, beyond 20% diminishes resistance. Reduction of the temperature of the surrounding air increases hypoxic resistance in direct proportion to the lowering of the air temperature.

127. VITAMIN DEFICIENCY AND "ALTITUDE" TOLERANCE IN RATS.[1] [2] Harry A. Charipper, E. D. Goldsmith and Albert S. Gordon, Washington Square College of Arts and Science, New York University.

Twenty-eight male rats, maintained on a synthetic diet deficient in vitamin B_1 for 6 weeks were divided into 2 groups. Thirteen rats were fed ½ mg. B_1 1 to 4 hours prior to low pressure exposure; the remaining 15 were untreated. Fifteen rats, in a third group, were fed a restricted amount of the synthetic diet, but with all vitamins present in adequate amounts, in order to induce a weight loss similar to that experienced by the B_1 deficient rats over the same period of time. In a 4th group, the complete synthetic diet together with an extra amount of B_1 (25γ daily) was fed to 15 rats. A 5th group comprised of 14 rats fed the complete synthetic diet ad lib and a 6th group of 15 rats given ordinary laboratory ration served as the controls. All animals were then exposed to a reduced barometric pressure of 190 mm. Hg (34,000 ft.). The B_1 deficient group was found to be the most resistant as judged by mean survival time. The rats fed the restricted complete diet were more resistant than those in the 2 control groups and in the hypervitaminized series. Adminsitration of B_1 prior to exposure reduced the tolerance of the B_1 deficient rats.

Similar series of animals subjected to vitamin B_2 or B_6 or pantothenic acid deficiency behaved no differently than the controls under conditions of reduced pressures. Large doses of these vitamins prior to pressure exposure were also without effect on tolerance.

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[1] Aided by a grant from the Commonwealth Fund.

[2] Animals and diets supplied by the Merck Institute for Therapeutic Research through the courtesy of Dr. H. J. Robinson and Mr. R. Stebbins.

128. THE PERSISTENCE OF A THYMUS REMNANT IN AGED RATS. Edmond J. Farris and Eleanor H. Yeakel, The Wistar Institute of Anatomy and Biology.

Dissection of the mediastinum of aged rats has shown that a definite structure identifiable as the remnant of the thymus may be found, similar in appearance to a thymus that has undergone severe accidental involution in a younger animal. The remnant consists of two narrow strips, tapering at the cervical end, and lying in a longitudinal position between the anterior mediastinal lymph nodes. Satisfactory dissection of the borders from the surrounding connective tissue is often difficult. Microscopically, concentric corpuscles of Hassall and lymphocytes are found within the structure.

The atrophied thymus was removed from fifty male and female Wistar albino rats, 553 to 1058 days old. In these animals, the organ weight did not vary with age. Average weight was 0.0300 gm, ± 0.0102 (standard deviation). The maximum weight observed was 0.0577 gm.; minimum, 0.0126 gm.

129. SEASONAL AND DIURNAL VARIATION IN ERYTHROCYTE COUNT IN THE DOMESTIC FOWL. Elsie Taber and L. V. Domm, Whitman Laboratory of Experimental Zoology, The University of Chicago.

To investigate the possibility of seasonal variation in erythrocyte concentration in the domestic fowl counts were made on brown Leghorn roosters, hens, capons and sinistrally and bilaterally ovariectomized poulards (12 each) in spring, summer, fall, and winter. In roosters counts were consistently high with little variation (3.26, 3.22, 3.29, and 3.28 million/cu. mm. respectively). In hens counts were lowest in spring during peak of laying period (2.59) and highest in winter (2.86). Counts on operated birds were as follows: capons 2.70, 2.58, 2.55, 2.49; sinistrally ovariectomized poulards 3.21, 2.97, 2.97, 3.18; bilaterally ovariectomized poulards 2.64, 2.58, 2.68, 2.46.

Additional counts were made at six-day intervals on two groups of 3 hens each, beginning the 3rd month of age (July and December) and continuing for 12 and 7 months respectively. Laying began at 6–9 months of age. In each case there was a drop in erythrocyte number immediately prior to and during laying. The averages of counts in groups 1 and 2 before laying were 2.44 and 2.71 respectively, while averages after laying started were 2.29 and 2.30. Observations were also made on two 14-month-old hens. The average of counts from December to April (sporadic laying) was 3.04, while during the spring laying period the average was 2.86.

To determine whether there is a diurnal variation in erythrocyte number, counts were made at six-hour intervals on 24 males and 12 females. Although there was considerable variation, there appeared a definite tendency for counts to be lowest at midnight and highest at noon or in the afternoon.

Morphology

130. Sexual dimorphism in sea-urchins. Albert Tyler, California Institute of Technology.

In the sea-urchins Lytechinus anamesus and L. pictus th esexes can be distinguished externally by the fact that the gonopores are considerably larger in the female than in the male.

131. The anatomy of the female American lac insect, Tachardiella Larrea. Harold S. Colton, Museum of Northern Arizona.

Specimens of the lac insect were collected at different seasons of the year on the creosote bush, Larrea tridentata, which grows on the deserts of western and southern Arizona. A study of the whole mounts and serial sections show that the alimentary canal has a continuous lumen from the mouth to the anus, passing through a pharynx, oesophagus, first filter chamber in the head of the rectum, ventriculus free in the haemocoel, second filter chamber in the rectum posterior to the first filter chamber, intestine free in the haemocoel, rectum, and anus. The central nervous system of the adult insect is complete consisting of a cerebral ganglion and a ventral ganglion connected by commissures. The alimentary canal, nervous system, and much of the muscular system disappear about a month before the young are born. Among the six types of epidermal glands, the perivaginal glands are unicellular and the giant stalked gland cells seem to have a duct within the cell leading from a vacuole to the exterior through a pore in the cuticle. As the young are born into a space between the insect and the lac test, the mother shrinks and in so doing withdraws the anal tubercle which has plugged the anal pore freeing the aperture and allowing the larva to reach the outside world.

132. On the origin of the nervous system of vertebrates. F. H. Pike, Columbia University.

Recent views on the fate of the blastopore and origin of mesoderm restrict search for vertebrate ancestry to Deuterostomia. A simple hypothesis of origin of the vertebrate nervous system is proposed.

Earlier investigators focussed attention on Enteropneusta. Similar but more primitive relations occur in Brachiopoda and Sagitta. A dorsal ganglion connected with a ventral ganglion by two lateral commissures occurs in both forms. A similar dorsal ganglion and two commissures appear in the dipleurula larva of crinoids, but disappear with no formation of a ventral ganglion. The dorsal ganglion is the sole source of innervation for mouth parts and alimentary canal of Sagitta (Burfield). This relationship is unknown or obscure in Brachiopogitta (Burfield). This relationship is unknown or obscure in Brachiopoda and Enteropneusta.

The dorsal ganglion of Enteropneusta is larger than the ventral, and more fibers to dorsal musculature arise from it than in Brachiopoda. Further increase in dorsal musculature accompanying origin and development of a notochord, with consequent increase in volume of innervation from the dorsal ganglion, and decrease in the ventral ganglion and commissures leading to eventual disappearance, would account for the origin of a dorsal nervous system. No new nervous system, or new alimentary tract, or turning over, is necessary. Problems of branchial origin and structure would be no more difficult than on any other hypothesis. The manner of origin of spinal nerve roots, and occurrence of giant cells and Rohon-Beard cells in Cyclostomes and other forms, would be susceptible of simpler explanation than is possible on other hypotheses.

133. Percentage weights of the major divisions of the brain in several species of animals.

Homer B. Latimer, University of Kansas.

The prosencephalon, mesencephalon, cerebellum and medulla are easily and quite accurately separated. In some of the larger brains the prosencephalon was further subdivided. The cerebellum and medulla were weighed together in the frog.

The percentages of the prosencephalon increase from 50% in the frog to 56% in the chicken; 67% in the turtle; 75% in the cat and to 83% in the dog.

The mesencephalon decreases in its relative weight. Its percentages are as follows: frog, 24; chicken, 21; turtle, 12; cat, 4; and 3% in the dog.

The percentages of the cerebellum vary, not with the development of the animal but rather in proportion to its activity. The slow turtle's cerebellum forms but 5% of the total brain weight; the dog, 10%; the more active chicken 13% and 14% in the cat.

The medulla shows a very regular series of decreasing percentage values, from 16% in the turtle; 10% in the chicken; 7% in the cat to but 5% in the dog.

The brain weights as percentages of the body weight vary from 0.09 in the heavy shelled turtle to 1.03 in the cat. There is less variation in the percentages of the cord. These vary from 0.10% in the frog to 0.14% in the turkey and in the dog, and to a maximum of 0.29% in the cat.

Parasitology

134. Duodenal mucus and age resistance to ascarids.

J. E. Ackert and L. P. Frick, Kansas State College.

From extensive experiments evidence supported by statistical analysis has been obtained which shows that duodenal mucus from old, resistant chicken differs both quantitatively and qualitatively from mucus of young chickens that are susceptible to the intestinal nematode, Ascaridia galli. Mucus from older chickens has been shown to inhibit the growth of A. galli when added in constant proportions to in vitro cultures of the worm. The results of separate tests have shown that the inhibitory agent present in the duodenal mucus is not of the nature and character of an anti-body since mucus which had been autoclaved at 15 pounds pressure for 20 minutes remained as effective as untreated mucus.

Extracting and filtering of the mucus indicate that the inhibitory agent is entirely contained in the fraction of the mucus which is soluble in 0.832 per cent saline. Results of tests on mucus from fowls infected with A. galli and from fowls of the same age that have never been infected indicate that the inhibitory factor does not depend upon previous or current infection of the host. The evidence indicates that the effects exerted on the worm by the inhibitory agent are nutritional in nature. In chicks a weak resistance to the growth of A. galli begins at about 4 weeks and increases gradually until a peak of maximum resistance is reached in fowls about 140 days of age. In the course of this period some as yet unknown substance appears to be secreted with the products of the goblet cells. This substance is thermo-stable and will pass through a filter.

135. The parasites of the Liopelmidae (Amphibia — Salientia — Amphicoela), and of the Pipidae (Amphibia — Salientia — Opisthocoela). A. C. Walton, Knox College.

The annotated list of the parasites of the Liopelmidae indicates the following host and parasite: (a) Ascaphus truei (U. S. A.) — Protoopalina stejnegeri (Protozoa). For the Pipidae the list indicates the following hosts and parasites: (a) Pipa pira (Brazil) — Agamonema pipae-dorsigerae and A. ranae-pipae (Nematoda); Monostoma sulcatum (Trematoda); and Flagellates of Geiman, 1934, and Haemogregarina sp? of Légèr, 1918 (Protozoa). (b) Xenopus calcaratus (Africa) — Balantidium and Nyctotherus spp? of Metcalf, 1923, and Protoopalina xenopodos (Protozoa). (c) Xenopus laevis (Africa) — Camallanus kaapslaadi and Procamallanus slomei (Nematoda); ? Brachycoelium sp? of Grobbelaar, 1922, Cercaria xenopi (in tadpoles), Diplodiscus doyeri, larval Echinostoma xenopi, Heterolope sp? of Grobbelaar, 1922, Metacercariae of Southwell and Kirschner, 1937, Opisthioglyphe endoloba, larval O. xenopi, Opisthodiscus subclavatus, Polystoma integerrimum, P. xenopi, larval Tylodelphys excavata from tadpoles (Trematoda); Cephalochlemys namaquensis and Chlamydocephalus xenopi (Cestoda); Amoeba sp? of Fantham, 1922, ? Balantidium entozoon, B. sp? of Mohr, 1942, B. sp? of Thomson, 1936, Giardia agilis (in tadpoles), Hexamita xenopi (n. comb. for Octomitus xenopi Fantham, 1923), Leishmania xenopi (n. comb. for Herpetomonas xenopi Fantham, 1922), Paranyctotherus kirbyi, Protoopalina xenopodos, Trichodina xenopodos and Trichomonas batrachorum (Protozoa); and Bacillus fulminans, Borrelia spp? (for Spirochaeta spp? of Fantham, 1924), Escherichia alba, Flavobacterium flavotenuae, Micrococcus xenopus and Vibrio xenopus (Bacteria). (d) Xenopus mülleri (Africa) — Procamallanus xenopodis (Nematoda). (e) Xenopus spp? (Africa) — Eberthella xenopa (Bacteria).

136. The parasites of the Discoglossidae (Amphibia — Salientia — Opisthocoela). A. C. Walton, Knox College.

The annotated list of the parasites of the Discoglossidae indicates the following hosts and parasites: (a) Alytes obstetricans (Europe) — larval Lecithopyge rastellum (Trematoda); Cepedia minor, Entamoeba ranarum, Karotomorpha bufonis Mastigamoeba hylae, Opalina cincta, ? Trepamonas agilis and Trichomonas prowazeki (Protozoa); Dermocystidium ranae (Phycomycetes); and Lucilia bufonivora (Diptera). (b) Bombina bombina (Europe) — Agamonema bombinatoris, Aplectana acuminata, Capillaria bombinatoris, Cosmocerca commutata, Hedruris androphora, Oswaldocruzia filiformis, Oxysomatium brevicaudatum and Rhabdias bufonis (Nematoda); Gorgodera cygnoides, Gorgoderina vitelliloba, Haematoloechus variegatus, H. v. abbreviatus, Hexathyridium affine, Monostoma ellipticum, Opisthodiscus subclavatus and larval Tetracotyle crystallina (Trematoda); Acanthocephalus ranae (Acanthocephala); and Balantidium elongatum, B. entozoon, Nyctotherus cordiformis, Opalina ranarum, Protoopalina caudata, P. intestinalis, Syndyomita neglecta and Trichomonas batrachorum (Protozoa). (c) Bombina maxima (China) — Protoopalina yunnanensis and P. y. cheni (Protozoa). (d) Bombina orientalis (China) — Protoopalina macrocaudata and P. orientalis (Protozoa). (e) Bombina pachypus (Europe) — Gorgodera cygnoides, Haematoloechus variegatus and Opisthodiscus subclavatus (Trematoda); and Entamoeba currens, E. ranarum, Karotomorpha bufonis, Protoopalina caudata and P. intestinalis (Protozoa). (f) Bombina sp ? (Europe) — Spironucleus elegans (Protozoa). (g) Discoglossus pictus (Africa) — larval Ratzia parva and larval Ratzia sp ? of Brumpt, 1936 (Trematoda); Entamoeba ranarum, Haptophrya gigantea, Karotomorpha bufonis, Opalina discoglossi, O. ranarum, Protoopalina caudata, P. c. discoglossi, P. intestinalis, Trichomonas duboscque, Trypanosoma parroti, T.

rotatorium and T. sergenti (Protozoa); and Batrachobdella algira (Hirudinea). (h) Discoglossus pictus (Europe) — larval Polystoma integerrimum (Trematoda); larval Diphyllobothrium erinacei (Cestoda); and Entamoeba ranarum, Karotomorpha bufonis, Opalina discoglossi, O. ranarum, Protoopalina caudata, P. c. discoglossi, P. intestinalis and Trypanosoma rotatorium (Protozoa).

137. The parasites of the Pelobatidae (Amphibia — Salientia — Anomocoela). A. C. Walton, Knox College.

The annotated list of the parasites of the Pelobatidae indicates the following hosts and parasites: (a) Aelurophyryne mammata (China) — ? Cepedia dimidiata (Protozoa). (b) Megophrys hasseltii (Java) — Cepedia hasseltii (Protozoa). (c) Megophrys montana — (Java) Protoopalina montana (Protozoa) and (Siam) Oxysomoides tuberculatus (Nematoda). (d) Pelobates cultripes (Europe) — Asymphlyodora tincae and Polystoma integerrimum (Trematoda); Protoopalina intestinalis (Protozoa); and Lucilia bufonivora (Diptera). (e) Pelobates fuscus (Europe) — Aplectana acuminata, Cosmocerca commutata, Oswaldocruzia filiformis, Oxysomatium brevicaudatum, Rhabdias bufonis and R. rubrovenosa (Nematoda); larval Distoma sp ? of Tiniofeev, 1900, larval Echinoparyphium recurvatum, Haplometra cylindracea and Polystoma integerrimum (Trematoda); Nematotaenia dispar (Cestoda); Amoeba limax, Balantidium entozoon, Cepedia dimidiata, Entamoeba ranarum, Euglena sp ? of Sassuchin, 1928, Eutrichomastix batrachorum, Giardia agilis, Hexamita intestinalis, Leptotheca ohlmacheri, L. ranae, Mastigamoeba hylae, Nyctotherus cordiformis, Opalina ranarum, Pracus sp ? of Sassuchin, Protoopalina intestinalis, P. pelobatidis, Trachelomonas sp? of Sassuchin, Trichodina pediculus and Trichomonas augusta (Protozoa); and Bathrachobdella paludosa and Haementeria costata (Hirudinea). (f) Pelobates larvae (Europe) — Hemiclepsis marginata (Hirudinea). (g) Pelodytes punctatus (Europe) — Chilomastix caulleryi, Karotomorpha bufonis and Nyctotherus cordiformis (Protozoa). (h) Pelodytes sp ? (Europe) — Spironucleus elegans (Protozoa). (i) Scaphiopus bombifrons (U. S. A.) — Diplorchis scaphiopi (Trematoda); and Protoopalina scaphipodos (Protozoa). (j) Scaphiopus couchii (U. S. A.) — Oxysmatium americana (Nematoda); Diplorchis americana (Trematoda); and Zelleriella couchii (Protozoa). (k) Scaphiopus hammondii (U. S. A.) — Opalina oblanceolata, Protoopalina hammondii and Trichomonas augusta (Protozoa). (l) Scaphiopus holbrooki (U. S. A.) — Agamascaris sp ? of Brandt, 1936, Cosmocercoides dukae, Oswaldocruzia leidyi, O. pipiens, Physaloptera sp? of Brandt, Rhabdias ranae and R. sp? of Brandt (Nematoda); Distoichometra bufonis and proteocephalid cysts of Brandt (Cestoda); and Cepedia flava, Hexamita intestinalis, ? Nyctotherus cordiformis, Opalina carolinenesis, O. oblanceolata, O. obtrigonoidea. O. triangularis, O. triangulata, Trichomonas augusta and Zelleriella scaphiopodos (Protozoa). (m) Scaphiopus holbrooki albus (U. S. A.) — Cepedia floridensis (Protozoa). (n) Scaphiopus multiplicatus (Mexico) — Aplectana hoffmanni and A. itzocanensis (Nematoda); and Protoopalina mexicana (Protozoa) (o) Scutiger alticolus (Tibet) — Oxysomatium tibetanum (Nematoda).

Protozoology

138. The early history of the genus Paramecium. Lorande Loss Woodruff, Yale University.

A survey of the important pioneer studies, with reproductions of figures, relative to the establishment of the genus Paramecium and the species now recognized as P. aurelia and P. caudatum, in a form readily available for students of the history of the confused taxonomy of the genus. To appear in the Transactions of the Connecticut Academy of Arts and Sciences.

139. Exchange of cytoplasm at conjugation in Paramecium aurelia, variety 4. T. M. Sonneborn, Indiana University.

The character "killer" depends upon the combined presence of a gene and a cytoplasmic factor. At conjugation, transfer of the gene demonstrates nuclear exchange; transfer of the cytoplasmic factor, cytoplasmic exchange. In conjugation between killer race 51 and non-killer race 32, the cytoplasmic factor is never transferred, though the gene regularly is. In conjugation between killer race 51 and other non-killer races (e. g. 29 or 47), the cytoplasmic factor is usually not transferred, but often is transferred. The transfer of cytoplasm is crudely measured by the extent of the time interval between separation of conjugants at their anterior ends and separation at their paroral cones, processes which follow soon after exchange of nuclei. When this interval is less than 3½ minutes, exchange of cytoplasm is not detected regardless of what races were crossed. The interval falls within this range invariably in the cross of 51 × 32, usually also in crosses of 51 to other races. When the interval is 20 minutes or more, cytoplasmic factor is invariably transferred. When the interval is between 3½ and 20 minutes, sometimes no cytoplasmic exchange can be detected; sometimes it can; usually there is evidence for transfer of smaller amounts of cytoplasm than when the interval is longer. Exchange of cytoplasm at conjugation thus never occurs in crosses of certain races (though nuclei are exchanged in these crosses); but does occur in a considerable proportion of pairs in crosses of other races.

140. The growth of Tetrahymena geleii in thiamine-free media. George W. Kidder and Virginia C. Dewey, Brown University.

Indefinitely transplantable growth of Tetrahymena geleii (strain W) can be obtained in dethiaminized (heated for 1 hour at 123°C. at pH 10) Harris gelatin plus riboflavin, inorganic salts and tryptophane. The generation time in this medium is about 5.5 hours, the population at the end of logarithmic growth approximately 2,500 cells per ml., the maximum yield 12,000 per ml. and the population at the end of 264 hours about 200 living ciliates per ml. The addition of thiamine does not effect the generation time nor the size of the population at the end of the logarithmic growth phase but the maximum yield is increased and population decline is lessened. The addition of dethiaminized alfalfa extract reduces the generation time to about three hours while the number of cells per ml. is greatly increased (20,000 at the end of logarithmic growth, over 80,000 as a maximum yield and 40,000 after 264 hours). The addition of thiamine with the alfalfa extract had no significant effect. Completely hydrolysed (refluxed in H_2SO_4) gelatin subjected to the heat treatment to render it thiamine-free failed to support growth when supplemented with riboflavin, thiamine, inorganic salts and tryptophane but gave excellent growth with dethiaminized alfalfa extract, riboflavin, inorganic salts and tryptophane (maximum yield of 160,000 cells per ml.). The addition of thiamine had no significant effect. These results show conclusively that thiamine is not a "growth factor," as defined by Lwoff, for this strain of Tetrahymena.

141. The apparent need of Glaucoma piriformis for calcium and iron. R. P. Hall and W. B. Cosgrove, New York University.

Glaucoma piriformis has been maintained by the serial-transfer technique in a "vitamin-free casein" medium supplemented with certain inorganic salts. This salt mixture has been replaced, with approximately the same results, by a calcium salt and iron salt (trace) and by a calcium salt containing an appreciable quantity of iron as a contaminant. Negative results were obtained with certain other salts used as supplements. Omission of the calcium and iron compounds from the original salt mixture, leaving only traces of iron and calcium, reduced the populations to a low level. These inorganic supplements were replaced successfully with a dethiaminized extract of alfalfa meal. Thus enriched, casein medium supported populations consistently approximating those obtained with the original salt mixture. Heavier growth was obtained with untreated extract of alfalfa meal and with a suspension of brewer's yeast as supplements to casein medium. Such organic preparations presumably contain the minerals in which the basal casein medium is deficient.

AUTHOR INDEX

Showing abstract numbers and pages for each author

Author	*Abstract No.*	*Page No.*
Ackert, J. E.	134	574
Adams, A. Elizabeth	103	562
Aronson, Lester R.	41	539
Barber, Lucie Welles	96	560
Barnes, T. Cunliffe	53, 54, 55	543, 544
Beach, Frank A.	25	536
Beams, H. W.	8, 9	531
Beck, Lyle V.	119	568
Belda, W. H.	87	557
Bennett, A. H.	65	547
Beutner, R.	54	543
Blivaiss, Ben. B.	111	565
Blum, Harold F.	12	532
Bodine, Joseph Hall	61	546
Bowen, W. J.	69	549
Boyden, Alan	118	568
Brambel, C. E.	90	558
Breneman, W. R.	30	538
Browman, Ludvig G.	43	540
Carpenter, Esther	99	561
Caspari, Ernst	57	545
Charipper, Harry A.	110, 113, 127	565, 566, 572
Clausen, H. J.	107	564
Colton, Harold S.	131	573
Cornman, Ivor	86	556
Cosgrove, W. B.	141	577
Cowles, R. P.	90	558
Davis, David E.	116	567
Dewey, Virginia C.	140	577
Domm, L. V.	111, 129	565, 572
Douglis Marjorie B.	36	551
Dunihue, F. W.	64	547
Elias, Hans	34, 81, 98	550, 555, 560
Elliott, Rush	63	547
Etkin, William	80	555
Eversole, Wilburn J.	108	564
Farner, Donald S.	92	558
Farris, Edmond J.	26, 45, 128	536, 540, 572
Fowler, Elizabeth H.	67	548
Frick, L. P.	134	574
Frisch, John A.	124, 125	571
Gaunt, Robert	115	567
Gay, Helen	10, 83	531, 556
Gehenio, P. M.	121	569

Author	*Abstract No.*	*Page No.*
Goldschmidt, Richard B.	101	561
Goldsmith, E. D.	110, 113, 127	565, 566, 572
Gorbman, Aubrey	104	563
Gordon, Albert S.	110, 113, 127	565, 566, 572
Gordon, Myron	82	555
Gowen, John W.	40	538
Guhl, A. M.	93	559
Hall, E. R.	35	550
Hall, R. P.	141	577
Hamilton, Howard L. (Captain)	97	560
Hard, Walter L.	13, 120	532, 569
Harrison, James A.	67	548
Hartman, Carl G.	27, 114	537, 567
Herrick, Earl H.	29	539
Hiestand, William A.	51, 52, 126	542, 543, 571
Hill, David Leal	61	546
Hines, Eileen B.	8	531
Hollaender, Alexander	10	531
Jahn, Theodore Louis	56	544
Jones, Edgar P.	48	541
Juhn, Mary	112	566
Karczmar, A. G.	59	545
Kaufmann, Berwind	10, 83	531, 556
Kavanagh, Virgene W.	78	554
Kidder, George W.	68, 140	548, 577
King, R. L.	9	531
Koppanyi, Theodore	49, 50	542
Lahr, Ernest L.	24	535
Latimer, Homer B.	133	574
Lavin, George I.	89	557
Leathem, James H.	109, 44	564, 540
Liling, Mildred	115	567
Littrell, Jae L.	114	567
Luyet, B. J.	121	569
Marsh, Gordon	60	546
Martin, Dorothy	114	567
Mast, S. O.	69	549
Metz, Charles B.	94, 117	559, 568
Miller, Helen Rogers	126	571
Miller, James A.	17	534
Mintz, Beatrice	31	538
Moore, John A.	15	533
Mothes, Arlene M.	103	562
Nelsen, Olin E.	106	563
Newell, Irwin M.	91	558
Pace, D. M.	87	557
Payne, Fernandus	105	563
Payne, L. F.	93	559
Payne, Nellie M.	38	550
Pfeiffer, Carroll A.	22	534
Pike, F. H.	132	573
Plagge, James C.	28	537

Author	*Abstract No.*	*Page No.*
Pollister, Arthur W.	89	557
Powers, E. L.	47	541
Reece, Ralph P.	78	554
Reese, Albert M.	100	561
Richards, Oscar W.	66, 84	548, 556
Riddle, Oscar	24	535
Romanoff, Alexis L.	11	532
Rose, S. Meryl	16	534
Sandow, Alexander	58, 59	545
Scharrer, Berta	42	539
Schneirla, T. C.	39	552
Scott, J. P.	74, 75	552, 553
Scott, John W.	73	552
Shettles, Landrum B.	85	556
Simmons, Geo. Finlay	23, 76	535, 553
Slobodien, H. D.	109	564
Sonneborn, T. M.	139	577
Stampfer, Joshua	48	541
Stilwell, E. Frances	88	557
Stokely, P. S.	47	541
Stunkard, Horace W.	33	550
Taber, Elsie	129	572
Tahmisian, Theodore Newton	61	546
Thornton, C. S.	95	559
Tschirgi, Robert D.	51, 52	542, 543
Tyler, Albert	117, 130	568, 573
Villee, Claude A.	102	562
Vogel, Howard H. Jr.	37, 74	551, 552
Walton, A. C.	135 136, 137	575, 576
Wang, Hsi	122, 123	570
Warren, D. C.	93	559
Weissenberg, J. Richard	32	549
Wilson, Francis H.	46, 79	541, 554
Witschi, Emil	14	533
Woodruff, Lorande Loss	138	576
Wright, Philip L.	77	554
Wulff, Verner John	56	544
Yeakel, Eleanor H.	45, 128	540, 572
Zangerl, Ranier	62	546

INDEX

ACTH, effect of, on anterior pituitary of adrenalectomized young male rat 163
Adrenal cortex of mammals. Cell replacement and its relation to zona glomerulosa in 1
Adrenals of hypophysectomized rats, influence of testosterone propionate on 155
ALMQUIST, JOHN O., AND FREDERICK N. ANDREWS. Effect of testosterone propionate on thermo-regulartory function of rat scrotum 125
AMERICAN ASSOCIATION OF ANATOMISTS. Proceedings, officers and list of members 361
AMERICAN SOCIETY OF ZOOLOGISTS. Officers, constitution and by-laws, proceedings and list of members 195
AMERICAN SOCIETY OF ZOOLOGISTS. Program and abstracts, officers and index of authors 515
Anatomy of tongue of domestic Norway rat 429
ANDREWS, F. N. See Kirkpatrick, C. M. 317
ANDREWS, FREDERICK N. See Almquist, John O. 125
ANSON, BARRY J. See Reimann, Arthur F. 495
Anterior pituitary of adrenalectomized young male rat, effect of ACTH on 163
Antigonadotropic sera. Ovarian hypertrophy in rates united in parabiosis with littermates treated with 277
Aponeurosis, conjoined vs. conjoined tendon 339
Argentaffin cells of gastric mucosa of rat 287
Auditory stimulation. Breeding and rearing of young by albino rats subjected to 325
Avian embryos, heart beat of 313

BARBER, LUCIE WELLES. Correlations between wound healing and regeneration in fore-limbs and tails of lizards 441
BASSETT, CHARLES F. See Pearson, Oliver P. 455
BEATON, LINDSAY E. See Reimann, Arthur F. 495
Blood cells in tissue cultures, locomotion of 43
Blood vessels of nerves, a method of visualizing 65
Body weights and organ measurements in relation to age and season in ring-necked pheasants 175
Brain, biaxiate, with paired hypophyses, of pig embryo 107
Breeding and rearing of young by albino rats subjected to auditory stimulation 325
BRIGGS, ROBERT, AND LOIS JUND. Successful grafting of frozen and thawed mouse skin 75

CAPILLARIES of central nervous system, injection and red-cell staining methods of 93
CAREY, EBEN J. Effects of inanition on the structure of motor end plates 139
Cat, clavicular ligaments of 23
Cell replacement and its relation to zona glomerulosa in adrenal cortex of mammals 1
Central nervous system. Injection methods used in capillaries of 93
CHANDLER, SIMON B. AND MELVIN SCHADEWALD. The inguinal region. I. Conjoined aponeurosis vs. conjoined tendon 339
Chimpanzee, genital cycles following incomplete oophorectomy in 475
Clavicular ligaments of the rat, rabbit, cat and dog 23
COBB, W. MONTAGUE. Apical pericardial adhesion resembling the reptilian gubernaclum cordis 87

DASELER, EDWARD F. See Reimann, Arthur F. 495
DAWSON, ALDEN B. Argentaffin cells of gastric mucosa of rat 287
DEBRUYN, P. P. H. Locomotion of blood cells in tissue cultures 43
Dog, clavicular ligaments of 23
DRUMMOND, STANLEY P. A comparison of injection and red-cell staining methods used in quantitative studies of capillaries of central nervous system 93
DUKE, KENNETH L. Activity of germinal epithelium in ovary of a pregnant harvest mouse 135
Duodenum, partial inversion of 71
Duplicitas anterior in the toad 345

EADIE, W. ROBERT. Tooth replacement in Brewer's mole 357
Eleutherodactylus alticola, duplicitas anterior in 345
EPSTEIN, JOSEPH. A method for visualizing the blood vessels of nerves and other tissues 65
Extremities, study of 1600, in man 495
Testosterone propionate on thermo-regulartory

FARRIS, EDMOND J. AND ELEANOR H. YEAKEL. Breeding and rearing of young by albino rats subjected to auditory stimulation 325
Fertility in the fox in relation to size of vulva 455
FINERTY, JOHN C. See Kupperman Herbert S. 277
FISH, H. S., P. D. MALONE AND C. P. RICHTER. Anatomy of the tongue of the domestic Norway rat 429
Fore-limbs of lizards. Wound healing and regeneration in 441
Formation and growth of adrenocortical-like tissue in ovaries of adrenalectomized ground squirrel 33
Fox, size of vulva in, and its relation to fertility 455

GASTRIC mucosa of rat, argentaffin cells of 287
Genital cycles following incomplete oophorectomy in chimpanzee 475
GEORGE, W. C. Pig embryo with bifid notochord, biaxiate brain with paired hypophyses 107
Germinal epithelium, activity of, in ovary of pregnant harvest mouse 135
Grafting of frozen and thawed mouse skin 75
GROAT, RICHARD A. Formation and growth of adrenocortical-like tissue in the ovaries of adrenalectomized ground squirrel 33
Ground squirrel, adrenalectomized. Growth and formation of adrenocortical-like tissue in ovaries of 33
Growth of adrenocortical-like tissue in ovaries of adrenalectomized ground squirrel 33
GRUENWALD, PETER, AND WILLIAM M. KONIKOV. Cell replacement and its relation to the zona glomerulosa in the adrenal cortex of mammals 1
Gubernaculum cordis, reptilian. Apical pericardial adhesion resembling 87
Guinea-pig, locomotion of blood cells in tissue cultures of 43

Guinea-pig spleen. Structure and connections of venous sinuses 413
Gysin, Helene M. See Littleford, Robert A. 507

HEART beat of avian embryos 313
Hypophyses, paired in brain of pig embryos 107

INANITION, effects of, on structure of motor end plates 139
Inguinal region, studies on 339
Injection methods used in capillaries of central nervous system 93
Inversion, partial, of duodenum 71

JUND, LOIS. See Briggs, Robert 75

KIRKPATRICK, C. M. Body weights and organ measurements in relation to age and season in ring-necked pheasants 175
Kirkpatrick, C. M., and F. N. Andrews. Development of testis in ring-necked pheasant 317
Koneff, Alexei A. Effect of adrenocorticotropic hormone on anterior pituitary of adrenalectomized young male rat 163
Konikov, William M. See Gruenwald, Peter 1
Kupperman, Herbert S., Roland K. Meyer and John C. Finerty. Ovarian hypertrophy in rats united in parabiosis with littermates previously treated with antigondotropic sera 277

LEATHEM, JAMES H. Influence of testosterone propionate on adrenals and testes of hypophysectomized rats 155
Ligaments, clavicular, of the rabbit, cat and dog 23
Littleford, Robert A. and Helene M. Gysin. Superfetation in mice 507
Lizards. Correlation between wound healing and regeneration in fore-limbs and tails of 441
Locomotion of blood cells in tissue cultures 43
Lynn, W. Gardner. Duplicitas anterior in the toad, Eleutherodactylus alticola 345

MAMMALS. Cell replacement and its relation to zona glomerulosa in adrenal cortex of 1
Man, palmaris longus and tendon in 495
Marchi-treated serial sections. Cellophane strip method adapted for study of 331
Meyer, Roland K. See Kupperman, Herbert S. 277
Mice, superfetation in 507
Mole, Brewer's, tooth replacement in 357
Motor end plates, effects of inanition on structure of 139
Mouse, pregnant, harvest. Activity of germinal epithelium in ovary of 135
Mouse skin, grafting of frozen and thawed 75
Muscle, palmaris longus, and tendon in Homo 495

NERVES. A method of visualizing blood vessels of 65
Notochord, pig embryo with bifid 107

OOPHORECTOMY, incomplete, in chimpanzee 475
Ovarian hypertrophy in rats united in parabiosis 277
Ovary of pregnant harvest mouse, activity of germinal epithelium in 135
Ovaries of adrenalectomized ground squirrel. Formation and growth of adrenocortical-like tissue in 33

PALMARIS longus muscle and tendon in Homo 495
Papillae, number and distribution, in tongue of rat 429
Parabiosis, ovarian hypertrophy in rats united in 277
Pearson, Oliver P., and Charles F. Bassett. Size of the vulva in the fox and its relation to fertility 455
Pericardial, apical, adhesion resembling reptilian gubernaculum cordis 87
Pheasant, development of testis in ring-necked 317
Pheasants, ring-necked, body weights and organ measurements in relation to age and season in 175
Pig embryo with bifid notochord, biaxiate brain with paired hypophyses 107

RABBIT, clavicular ligaments of 23
Rabbit, locomotion of blood cells in tissue cultures of 43
Rasmussen, Grant Litster. Cellophane strip method especially adapted for Marchi-treated serial sections 331
Rat, anatomy of tongue of domestic Norway 429
Rat, clavicular ligaments of 23
Rat scrotum, effect of testosterone propionate on thermo-regulatory function of 125
Rat thyroids activated by thiourea. Secretion antecedents of 461
Rat, young male. Effect of ACTH on anterior pituitary of adrenalectomized 163
Rats, albino, breeding and rearing of young by, subjected to auditory stimulation 325
Rats, influence of testosterone propionate on adrenals and testes of hypophysectomized 155
Rats, united in parabiosis with littermates previously treated with antigonadotropic sera. Ovarian hypertrophy in 277
Regeneration in fore-limbs and tails of lizards 441
Reimann, Arthur F., Edward H. Daseler, Barry J. Anson and Lindsay E. Beaton. Palmaris longus muscle and tendon. Study of 1600 extremities 495
Renal fascia and its relation to transversalis fascia 295
Romanoff, Alexis L. Heart beat of avian embryos 313

SALTZMAN, ABRAHAM. See Sandstrom, Carl J. 23
Sandstrom, Carl J. and Abraham Saltzman. A comparative study of the clavicular ligaments of rat, rabbit, cat and dog 23
Schadewald, Melvin. See Chandler, Simon B. 339
Scrotum, rat, effect of testosterone propionate on thermo-regulatory function of 125
Secretion antecedents of rat thyroids activated by thiourea 461
Skin, mouse, grafting of frozen and thawed 75
Skin of tongue in domestic Norway rat 429
Snook, Theodore. Guinea-pig spleen. Structure and connections of venous sinuses 413
Spleen, guinea-pig 413
Staining, red-cell, methods used in capillaries of central nervous system 93
Structure and connections of venous sinuses in guinea-pig 413
Superfetation in mice 507

TAILS of lizards. Wound healing and regeneration in 441
Tendon, conjoined, vs. conjoined aponeurosis 339
Tendon, palmaris longus muscle and, in Homo 495
Testis, development of, in ring-necked pheasant 317
Testes of hypophysectomized rats, influence of testosterone propionate on 155
Testosterone propionate, influence of, on adrenals and testes of hypophysectomized rats 155
Testosterone propionate on thermo-regulatory function of rat scrotum, effect of 125
Thermo-regulatory function of rat scrotum. Effect of testosterone propionate on 125
Thiourea. Secretion antecedents of rat thyroids activated by 461
Thomas, Owen Lewis. A cytological study of the secretion antecedents of rat thyroids activated by thiourea 461
Thyroids, rat, activated by thiourea. Secretion antecedents of 461

Tissue, adrenocortical-like, formation and growth of, in ovaries of adrenalectomized ground squirrel 33
Tissue cultures. Locomotion of blood cells in 43
Toad, duplicitas anterior in the 345
TOBIN, CHARLES E. Renal fascia and its relation to transversalis fascia 295
Tongue, anatomy of, in domestic Norway rat 429
Tooth replacement in Brewer's mole 357
Transversalis fascia. Renal fascia and its relation to 295

VENOUS sinuses in guinea-pig, structure and connections of 413
Visualizing blood vessels of nerves, a method of 65

VON BONIN, GERHARDT. Partial inversion of duodenum 71
Vulva, size of, in the fox and its relation to fertility 455

WOUND healing and regeneration in forelimbs and tails of lizards. Correlation between 441

YEAKEL, ELEANOR H. See Farris, Edmond J. 325
YOUNG, WILLIAM C. Genital cycles following incomplete oophorectomy in chimpanzee 475

ZONA glomerulosa in adrenal cortex of mammals. Cell replacement and its relation to 1

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